TOPICS OF THE MONTH

More university-trained chemical engineers needed

BRITAIN'S desperate shortage of engineers and technologists, and of the means for training them, has been well aired recently, and the country's plight has been thrown into relief by accounts of the immense technological progress that has been made in Russia and the United States. A fact which is sometimes overlooked, and which adds to the seriousness of the situation, is that Britain, dependent to a great extent on imports, has a much more vulnerable economy than these other vast territories with their rich store of natural resources.

When this aspect is pointed out by so prominent an industrial figure as Lord Chandos, chairman of Associated Electrical Industries Ltd., it gives plenty of grounds for concern. But, as he says, mere realisation of the problem is not enough and effective action must be taken to overcome it.

One thing that must be done is to increase the number of engineering graduates and this includes, among other things, increasing the number of students that the universities are able to take—which at the moment is a deplorably low figure. And so it was that, at a recent gathering at University College, London, Lord Chandos supported Lord Strang in asking for industry's support for a £2-million project to increase the accommodation and facilities of the College's engineering departments. Lord Strang, who is chairman of the Engineering Appeal Committee, pointed out that industrial firms, both great and small, will receive the direct benefit from the increased output of engineers. University College plans to double its present output of engineering graduates in time, but financial support from outside the University is essential.

During World War 2, University College was damaged more than all similar institutions in Britain put together, and, of all the engineering departments, the hardest hit was the Chemical Engineering Department, of which only a shell remained. The greater part of the Chemical Engineering Department has since been restored but, in common with the other departments of the Engineering Faculty, it is still too small and overcrowded.

This is a sad state of affairs for a department of such long standing and of such fine traditions. During the 1914-18 war University College carried out important research on the German Haber process for obtaining nitric acid (an important war material) from the atmosphere. This operation led to the realisation of the prolonged research needed to translate a laboratory discovery into a mass-production technique, and it was seen that the country lacked men trained for this work. This realisation led to the founding of the Institution of Chemical Engineers in 1923. In the same year the sum of £50,000 raised as a memorial to Sir William Ramsey, discoverer of the rare gases and Professor of General and Inorganic Chemistry at University College from 1887 to 1913, provided an endowment for Britain's first Chair of Chemical Engineering at the College. Today, under Professor M.B. Donald, the Chemical Engineering Department has a very progressive outlook and is doing a great job of work in turning out chemical engineers of good all-round ability, for all engineering undergraduates at the College take a general course of training which is designed to avoid undue specialisation. It is significant that the list of firms who have responded to the College's appeal so far includes hardly one that does not make considerable use of chemical engineers.

Synthetic rubber projects in Japan

TWO Japanese industrial groups plan to start production of synthetic rubber by 1958, combining imported manufacturing techniques with raw materials supplied from a petro-chemical industry which is making its début in Japan. One of the two groups, which has the Mitsubishi Petrochemical Co. as its nucleus, will begin building facilities this year, at a total cost of 11,100 million yen (1,000 yen = £1), capable of producing 15,000 tons of GR-S in 1958.

The other group, formed by eight industrial companies formerly affiliated with the Furakawa interests, plans to manufacture 15,000 tons of GR-S, 1,500 tons of GR-1, 600 tons of *Hycar* and 5,000 tons of *Ameripol SN*.

The demand from Japanese rubber manufacturers for synthetic rubber has been increasingly appreciably and manufacturers of motor tyres appear to have started using it. The surprising estimate has been made that Japanese imports of synthetic might increase to more than 8,000 tons if supplies are available, while actual imports last year totalled 4,000 tons. However, an earlier estimate set this year's probable figure at 5,000 tons.

FEWER PAGES IN C.P.E. THIS TIME

*O*WING to the continuance of the dispute between the British Federation of Master Printers and the Typographical Association (one of the printing-trade unions) we have been obliged to make a considerable reduction in the size of CHEMICAL & PROCESS ENGINEERING this month. However, while the total number of pages devoted to articles and features has been reduced, we have made every effort to preserve the usual variety.

We apologise to readers for the limitations which are imposed on us by circumstances which are completely outside our control, and assure them that we shall resume normal publication as soon as the dispute has been settled.

Chemical-resistant concrete

A METHOD of treating concrete to give it greater resistance to chemical attack, known as *Ocrating*, has been developed in the Netherlands. It is well known that the setting and hardening of cement is accompanied by heat-releasing chemical reactions where the complicated calcium compounds in the cement are partly transformed into simpler compounds from which the calcium is very easily removed, chemically or physically: the calcium is 'washed out.' This process tends to weaken the resistance of the concrete against chemical influences, including those of atmospheric agents, subsoil water, smoke gases, etc. Such aggressivity can be reduced if the quantity of free calcium in the cement can be reduced.

Many years ago, the knowledge of these phenomena led to the treatment of the concrete, before hardening, with aqueous solutions of metal compounds of hydro-fluoro-silicic acid which form, together with the free calcium, compounds of greater chemical resistance than that of the original calcium compounds (calcium fluoride, magnesium fluoride, silicic acid). Moreover, these substances are harder and less soluble. This treatment, however, has certain drawbacks, one of them being that the effect remains largely confined to the surface layer of concrete as the pores are fairly rapidly 'choked'.

It is stated that these drawbacks are avoided in a new method, in which the concrete is treated, after hardening, with silicon tetrafluoride (SiF_4) gas, with the result that the calcium compounds are transformed into hard, insoluble substances with high resistance against chemical aggressivity.

As this treatment takes place in a vacuum or under pressure, the gas is able to penetrate deeply. Moreover, as the treatment is applied after drying, the formation of hydrates in the capillaries is a much slower process than with the older methods, so that the pores remain open longer. These hydrates, incidentally, contain mainly silicic acid so that their structure resembles that of the substances formed during the original hardening.

South American cement industry openings

B RITISH exporters of chemicals, capital machinery and other goods have been taken to task by more than one critic lately for not paying more attention to South American markets. For any industrial interest with a mind to invest in the cement industry in Ecuador, Peru, Bolivia or Colombia, a recent survey neatly summarises the prospects. The most favourable circumstances seem to be those in Bolivia, whose Government, apparently, are most anxious to encourage the investment of private capital, foreign or otherwise, in the development of the cement industry. The only cement factory in production there at present is antiquated, and there is a danger that its failure would leave the country without any supply of cement. Another factory under construction is expected to be completed this year, while a French firm is interested in establishing a further factory. It is stated that there is a substantial unsatisfied demand for cement and an abundance of suitable raw materials. However, the labour situation would need careful study, and also the Government's strict control over foreign exchanges.

In Peru there are two cement plants in production with other projects under way. It is not known whether there is any existing legislation which would hinder or especially favour foreign investment in this field, but there are no exchange or important restrictions in force in this country at the present time. A project for the establishment of a new factory would, no doubt, encounter a certain amount of hostility from existing concerns.

In Ecuador, it is thought that present facilities and others under construction should combine to meet the country's requirements for the next 10 years. Although the position is not known for sure, it seems unlikely that the Government would obstruct investment in the cement industry.

Finally, in Colombia, it is thought that special incentives by the national Government for the encouragement of the cement industry are remote. Beyond heavy tariff barriers, no further aid can be envisaged. The local departmental governments offer as inducements to industry special tax concessions in the hope of attracting the establishment of industries in their areas. There is such a demand for cement in Colombia that the local production has been unable to keep pace.

More information can be obtained from the Export Services Branch of the Board of Trade, London, W.C.1.

Comical Engineering Situations

"IT'S THE CHIEFS IDEA — GIVE HIM HIS HEAD, HE SAYS, HE MAY HAVE SOMETHING"

EVAPORATION

Fifth review of progress in the design and operation of evaporators

By J. M. Coulson, M.A., PH.D., D.I.C., M.I.CHEM.E.

EVAPORATORS have been in use in the chemical and allied industries for a number of years and on the whole improvements in design and in techniques of operation have been evolved gradually, from experience, rather than from the application of fundamental research work. Fairly frequent references are still being made to the problem of scale removal or prevention and suggestions are made for modifications in the design of what may be called standard types of units. There is little detailed published work on the performance of industrial units and without this it is difficult to see to what extent any fundamental work on the more general problem of boiling liquids can be applied.

In this review a paper from the salt industry is used to show how progress is being made in an industry in which evaporation is one of the main processes. Following this, reference is made to the use of new or recent types of equipment, to the problems of scale, and to some operation techniques. On the theoretical side the important features of a recent research paper by the author on the climbing film evaporator are discussed and a summary is given of an interesting paper by Prof. Gilliland on the general question of the provision of fresh water.

Manufacture of salt

The present trends in the salt industry are described in a paper by Hester and Diamond[1] in which they explain the installations at the Manistee plant of the Morton Salt Co. in America. Some 90% of the salt is produced by the vacuum pan process.

There are seven units arranged to make one triple effect and one quadruple effect system. A typical evaporator is illustrated in Fig.1. These evaporators are of the vertical calandria type with steam condensing outside the tubes and with an agitator fitted to improve circulation. The body and tube sheets are of cast iron and the tubes of copper. The calandria is 18 ft. in diameter and the central down-

take tube 8 ft. 10 in. in diameter. There are 2,240 tubes of $2\frac{1}{2}$ in. o.d. and $4\frac{1}{2}$ ft. in length giving a heating surface of 6,600 sq.ft. The agitator is 8 ft. in diameter and has four blades with a pitch of 12 ft. 6 in. and is driven at 36 r.p.m. As usual in this industry the arrangement is one of parallel feed and the operating conditions are shown in Table 1.

The heat transfer coefficient varies

BRINE LEVEL

SALT LEAVING EVAPORATOR

SALT PUMP
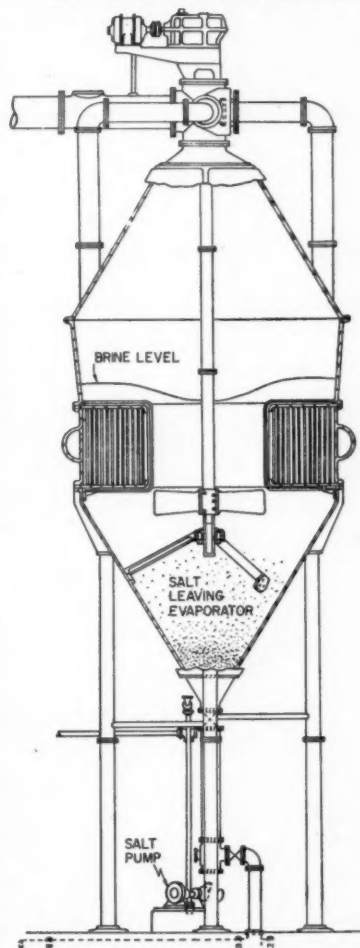
[Courtesy: Ind. & Eng. Chem.]
Fig. I. Schematic drawing of a vacuum pan.

in the three pans and average values are given in the last column of the table.

In operation the salt crystals which form remain in the unit until they are large enough to sink to the bottom as a slurry which is removed by centrifugal pump. The mother liquor contains calcium sulphate in solution and the crystals of salt are washed with fresh brine which removes this sulphate. The brine then passes on as feed to the evaporator so that the calcium sulphate builds up inside the unit which has eventually to be stopped for cleaning. Scaling is minimised by providing sufficient salt and calcium sulphate suspension to reduce supersaturation to non-scaling levels. The use of liquid-level controllers and the control of salt suspension has helped in increasing output. There is as yet no simple means of regulating the particle size for granulated salt and this is determined largely by the circulation rate in the pans, the quantity of salt, and the location and size of the propellers. The article contains a reference to the introduction of a newer type of evaporator using forced circulation through external heat exchangers: whilst they do not apparently give significantly better results than the latest type of vertical unit with internal agitators they have the great advantage of much easier access for repairs.

The relatively small amount of grainer salt made by the Manistee Co. is obtained by using long shell pans 120 ft. long, 16 ft. wide and 2 ft. deep. Each pan will produce about 30 tons/day of salt which crystallises out as air circulates over the surface of the brine. The salt leaving the grainer requires careful handling to avoid breakage of the crystals and pumps from the Manistee Iron Works or the Worthington Pump & Machinery Corporation are used.

Equipment

R.P. DeVries[2] describes a single-shell, quadruple-effect evaporator which is useful where floor space is

limited. This is illustrated in Fig.2 from which it is seen that a single vertical shell is subdivided to provide four separated units. Mounted on and around the shell is an annular steam or vapour chest (6) which supplies steam to each of the calandrias. Steam enters the first calandria through a tangential delivery pipe (5) so that the delivered steam will flow in whirling motion within the steam chest. That portion of the wall of the shell which bounds the heating section of the first effect (I) is provided with a number of intake ports through which steam is delivered into the interior of the heating section.

Vapours rising from the liquid of the first, second and third effects pass through the circumferentially spaced openings and curved discharge nozzles (7) tangentially directing the entering steam or vapour towards the outer wall of the steam chest (6). In this way entrained liquid is thrown against the wall of the steam chest and returns to the evaporator chamber from whence it came (trap 8).

A number of advantages are claimed for this type of construction which may prove of interest quite apart from the saving in floor space.

An increase in use of the Luwa evaporator in which thin films are used, (Fig.3.), and which was described in CHEMICAL & PROCESS ENGINEERING 1953, **34** (7) 200, has been reported in America.[3] Reference is made to four *Turba-Film* units each 19 ft. by 2½ ft. in diameter evaporating 3,000 lb./hr. of water, reducing the water content of a fertiliser slurry from 20 to 6%. The very short residence time, believed much less than 20 sec. even with viscous material, is one of the attractive features of this unit to rubber producers who are said to be using this form of evaporator for concentrating natural and synthetic rubber latex. With natural rubber they report feed rates as high as 180 lb./hr.sq.ft. when stripping ammonia from the latex at 100°F. Transfer coefficients of 300 B.Th.U./hr.sq.ft. are quoted for these conditions and 230 when concentrating vitamin extracts. Nearly all units are at present manufactured from stainless steel, which means they are expensive. Accurate control of the unit is essential since any changes in evaporation will tend to upset the rate of agitation and stirring.

Entrainment

Interest is still being shown in the entrainment that arises with most types of evaporators. This is particularly important in connection with

Table I. Some Operating Conditions for Triple Effect Evaporator Concentrating Brine[1]

Steam to first effect: 54,000 lb./hr. 220°F. Total production: 21 tons/hr.

Effect	Brine Temp. °F.	Temperature difference	Boiling point rise °F	% of salt made	Brine Level. In above Calandria.	Transfer coefficient B.Th.U./ hr.sq.ft.°F.
1	200	20	17.3	38.9	22	390
2	159	23.7	16.4	32.5	18	290
3	114	28.6	15	28.6	13	210

Table 2. Relative Efficiencies of Three De-Entrainment Devices[4]

System: Fission product solution, boil-up rates of approximately 10.65 lb./hr.sq.ft.

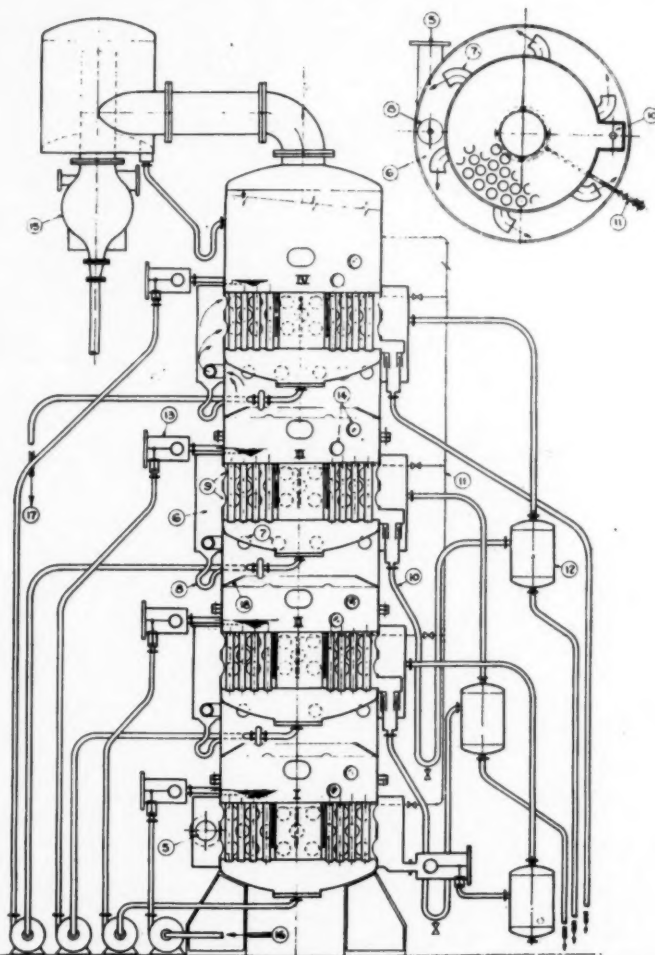| De-entrainment Device	Average Over-all Decontamination Factor (still-pot concentration/overhead concentration)
8.8 ft., ½″ Raschig rings	9×10^5
13 plates, 2″ bubble caps	6×10^6
4.5 ft., 20μ *Fiberglas*	4×10^7

Fig. 2. Single shell quadruple effect evaporator. (I, II, III, IV) Evaporating effects; (5) Steam inlet; (6) Annular vapour belt; (7) Vapour outlet; (8) Entrainment return; (9) Vapours to tubes; (10) Condensate discharge; (11) Non-cond. gas relief; (12) Cond. flash tank; (13) Liquid level control; (14) Sight glasses; (15) S. & K. condenser; (16) Light liquor inlet; (17) Heavy liquor outlet; (18) Conical baffle.

the concentration of radio-active waste. Manowitz[4] gives some results of work in which he used a submerged coil evaporator of 29 in. diameter and 50 in. high fitted with a $1\frac{1}{2}$-in. copper coil of 6 sq. ft. surface. He states that the average concentration of radio-active waste was 3×10^{-6} curies ml., and the maximum concentration of waste that can be disposed of is 3×10^{-12} so that a very substantial change in the de-contamination is required.

Three types of entrainment devices were studied—a column filled with Raschig rings or *Fiberglas*, or alternatively a column containing 13 bubble cap trays. Some of these results are shown in Fig. 4 They were able to express the decontamination factor, D.F. as

D.F. (evaporator) =

$$\frac{\text{still-pot activity ml.}}{\substack{\text{evaporator vapour activity ml.}\\\text{(condensed)}}}$$

where D.F. $= 4 \times 10^3 G^{0.75}$ (low boil-up rates to splash point)

and D.F. $= 1 \times 10^{10} G^{-3.5}$ (above splash point)

and G $=$ boil-up rate in lb./hr. sq. ft. of disengaging area

The effect of these entrainment devices can be seen from Table 2.

Scaling

The problem of scaling, particularly with sugar concentrations, has been discussed by a number of workers. Douwes Dekker[5] of the Sugar Milling Research Institute gives a long account of some work carried out on some evaporators in Natal. Details are given of the total weight and composition of the scale from a number of individual units. The weights of scale deposited in one week were determined in 1952 by collecting samples from 15 tubes. Some of the results are shown in Table 3.

The most important group of components forming the scale are the lime salts, silica and organic matter. It is suggested that normal figures for the rate of scaling of evaporators are 5 to
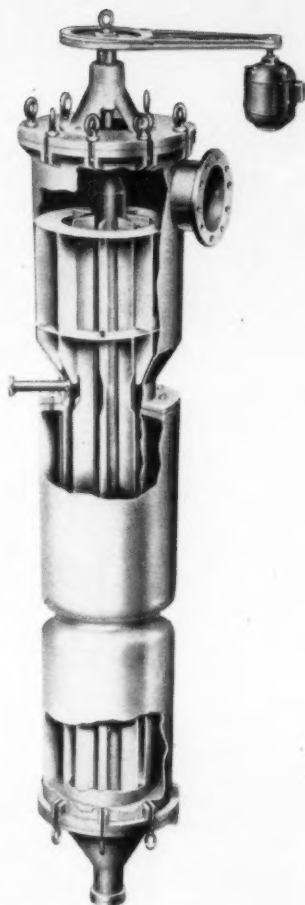

Fig. 3. Evaporator by Luwa S.A. in which thin films are employed.

15 parts of scale per million parts of water evaporated and 20 to 60 parts for No. 4 vessel. Although these amounts appear to be quite reasonable, examinations of this kind are valuable in giving some quantitative picture of the question of scaling.

This question is also discussed by Springer[6] in connection with the work of the West Indies Sugar Corporation. The preheater of a quadruple evaporator required cleaning out every three

days or so, and he describes some experimental work on the use of electric potentials and the effect of adding aluminium ions in the form of aluminium sulphate. If the rate of heat transfer immediately after cleaning is taken as a hundred then the influence of these two techniques can be seen from Tables 4 and 5

The scale index is defined as the percentage of the heat transfer coefficient obtained compared with the heat transfer coefficient on the day following cleaning.

Although these results are taken over long periods with changes in the juice there is evidence of the advantage in operation by the treatment of the juice. Some discussion is given by Springer of the cost of such treatment, which looks favourable. The importance of work of this kind is that it brings to the fore the importance of the problem and does suggest that more could be done to improve the running of these heat transfer units.

The effect of the addition of various chemicals in minimising scale formation in cane sugar factories is also described by N. R. Schmidt and L.F. Wiggins[10]

Theoretical

Coulson and McNelly[7] have given a further paper describing their work on heat transfer in a small climbing film evaporator using in the main silver tubes of $5\frac{1}{4}$ ft. in length and of diameters from $\frac{1}{2}$ to 1 in. They have proposed that the heat transfer process can be considered in three stages as indicated in Fig. 5. Over the region AB with low temperature difference the values of the transfer coefficient are substantially higher than those obtained with nucleate boiling for the same value of $\triangle t$ The mean slope of these correspond to the relation h_b $\alpha \triangle t^{0.53}$. They suggest that over this range of operation the two-phase flow is in the form of a thin liquid film with a major central vapour core into which most of the liquid is entrained as droplets. The important feature of the generation of the vapour is that it acts as a vapour lift pump and brings

Table 3. Scaling in Cane Sugar Evaporation[5]

Total weights, and weights per square foot H.S. of scale deposited in one week in No. 3. and No. 4. vessels respectively

Name of Factory	ZM	FX	AK	MV	TS	SZ(small quad.) (1)	(2)	(3)	SZ(large quad.) (1)	(2)	(3)
No.3. vessel, total wt.(tons)	0.015	0.21	0.046	0.074	0.158	0.022	0.004	0.013	0.002	0.006	
No.3. vessel, g per sq.ft.H.S.	2.31	32.9	6.32	29.2	23.9	10.2	1.91	5.82	0.38	1.57	
No.4. vessel, total wt(tons)	0.018	0.484	0.401	0.267	0.228	0.137	0.052	0.126	0.063	0.283	0.252
No.4. vessel, g per sq.ft.H.S	2.69	75.8	55.2	104.7	34.5	62.6	23.6	57.3	15.5	69.5	61.9

Note. The total weight figures for ZM refer to the last and penultimate vessels; those for FX to the last and penultimate vessels of No.1. triple effect; those for TS to the McNeil quad.

about a kind of forced convection heat transfer. On this basis they have suggested that the heat transfer process in this section can be analysed much in the same way as for heat transfer to boiling liquids under conditions of forced convection. Some results for water, isopropyl alcohol and ethy alcohol are shown in Figs. 6, 7, and 8, which in general conform to the relation of Fig.5. They have presented a general correlation for these conditions as below:

$$Nu = (1.3 + Cd) \left\{ Pr_L{}^{0.9} \cdot Re_L{}^{0.23} \cdot Re_v{}^{0.31} \cdot \left(\frac{\rho_L}{\rho_v} \right)^{0.25} \cdot \left(\frac{\mu_v}{\mu_L} \right) \right\}$$

where

Nu = Nusselt No. for liquid flow

$$= \frac{h_b \cdot d}{k_L}$$

Pr_L = Prandtl No. for liquid $= \dfrac{C \cdot \mu_L}{k_L}$

Re_L = Reynolds No. for liquid $= \dfrac{4 \cdot N_f}{d \cdot \mu_L}$

where N_f = feed rate in lb./hr.

Re_v = Reynolds No. for vapour

$$= \frac{Q \cdot L}{\lambda \cdot \mu_L}$$

where Q = heat flux/cond. area
L is length of tube
λ is latent heat of evaporation B.Thu./lb.

$\rho_L \cdot \rho_v$ = density of liquid and vapour.
$\mu_L \cdot \mu_v$ = viscosity of liquid and vapour.
k_L = thermal conductivity of liquid
C = const. = 39 ft.$^{-1}$ where d is tube diam in ft.
h_b = boiling film coefficient. BThU/hr. sq. ft. F.

Over the medium temperature range of region BC in the figure we find conditions corresponding to nucleate boiling and it has been shown that the results with the climbing film evaporator can be expressed with the same form of expression as presented earlier for nucleate boiling. This is given in the equation:

$$\frac{h_b \cdot d}{k_L} = 0.225 \left[\frac{c \cdot \mu}{k_L} \right]^{0.69} \cdot \left[\frac{Q \cdot d}{\lambda \cdot \mu} \right]^{0.69} \cdot \left[\frac{P \cdot d}{\sigma} \right]^{0.31} \cdot \left[\frac{\rho_L}{\rho_v} - 1 \right]^{0.33}$$

where. P .. vapour pressure of liquid; σ .. surface tension from vapour to liquid.

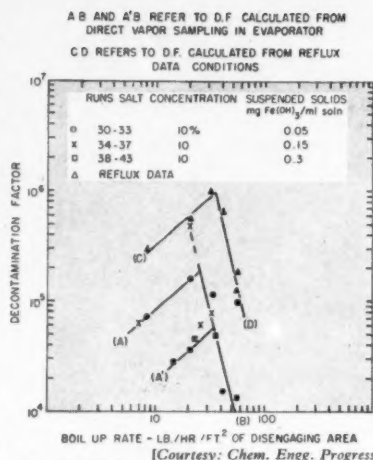Over the region AB the main turbulence produced arises from the forced convection due to the formation of

A B AND A'B REFER TO D.F. CALCULATED FROM DIRECT VAPOR SAMPLING IN EVAPORATOR

C D REFERS TO D.F. CALCULATED FROM REFLUX DATA CONDITIONS

Fig. 4. Effect of boil-up rate on the decontamination factor for liquid entrainment-submerged coil evaporator.

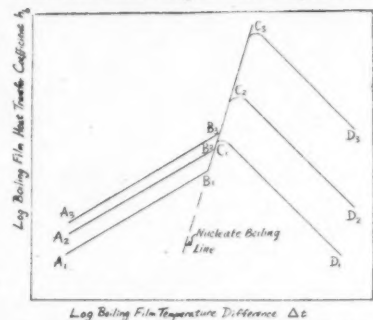**Fig. 5. General form of relation between film transfer coefficient and film temperature difference for climbing film evaporator.**
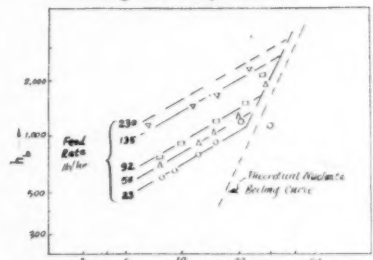

Fig. 6. h_b—$\triangle t$ for water boiling at 180° F in ½ in. i.d. silver tube.

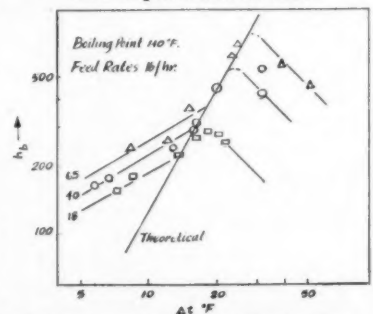**Fig. 7. Isopropyl alcohol in ½ in. silver tube.**

ever increasing quantities of vapour but over the range BC the main turbulence is obtained by the generation of increasing numbers of small drops and not by the forced convection effect. In operating the climbing film evaporator we shall normally be working over the range AB. The drop in the transfer coefficient over the final range CD arises from the fact that all of the liquid has been vaporised and there can be no more increase in heat flux.

The problem of providing fresh water for various purposes is discussed at length in a very interesting paper by Gilliland[8] Of particular interest to those concerned with the design of evaporators is his comment on the separation of water from sea water. Quite apart from the problems of handling the enormous quantities of salt that would be obtained and the considerable pumping required the theoretical work required for separating water is quite considerable. The power required to separate 1,000 gal. of sea water in a differential or batch process is shown by Gilliland (Fig. 9). Such a process is considered possible for the provision of water for household purposes.

Two main types of processes are used in the separation of salt solutions: those which separate water from a concentrated brine and those which actually remove the salt from the water. In the former we have the important field of evaporation which suffers in general from the high heat consumption and problems of corrosion and fouling of the heat transfer surfaces. For a single stage evaporator the heat required per 1,000 gal. is given as about 8.5 x 10⁶ B.Th.U. and although the heat has only to be degraded a few degrees for this process it has been found difficult to develop systems which are effective thermodynamically. For this reason a multi effect unit has been developed since this enables re-use of the heat to be effected.

Sherwood has estimated the net cost as 3.8$ per 1,000 gal. of water for this type of operation (based on American charges). Some cost data for large size units with 10,000 sq. ft. of surface have been given as approximately $1½/sq.ft. for steel and $2½/sq.ft. for copper tubes. The final installed costs of the units are of the order of $5/sq.ft.

Gilliland goes on to discuss in some detail the general cost for producing fresh water from sea water on this basis. In considering the vapour recompression evaporator he shows (see curves in Fig. 10) the effect of the temperature difference and tempera-
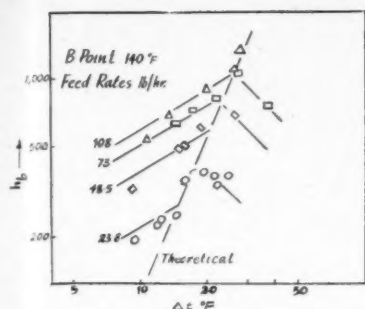
Fig. 8. Ethyl alcohol in ½ in. silver tube.
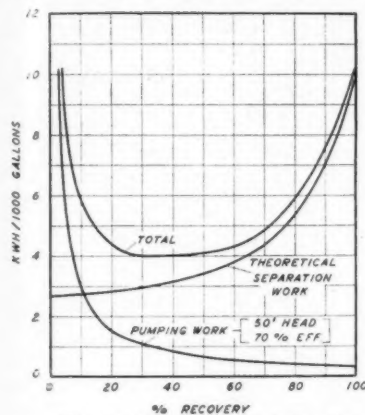

[Figs. 9 and 10, courtesy: Ind. & Eng. Chem.

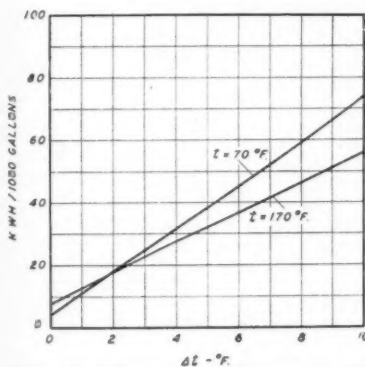Fig. 9. Work for differential separation of sea water.

Fig. 10. Effect of temperature difference and temperature level on work for vapour compression evaporator.

ture level on the work required for vapour recompression. He concludes with a general discussion on the possibility of using either demineralisation techniques such as adsorption, solvent extraction and ion exchange. This paper should be read by all interested in evaporation since it brings out the relationship of this particular technique to a number of other methods which are frequently available for the same purpose.
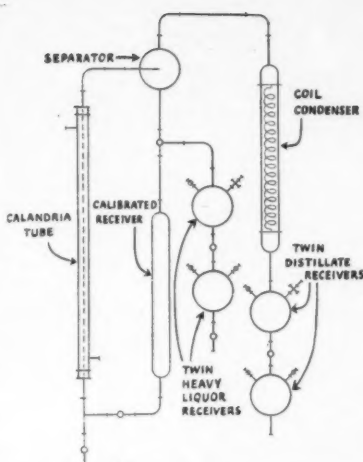
Some of these problems have been

Fig. 11. Diagram showing arrangement of a glass laboratory climbing-film evaporator marketed by Q.V.F. Ltd. The unit is suitable for heating with 25 lb. pressure steam and can be used under a vacuum or under pressures of up to 70 p.s.i.

discussed in papers by Leicester[9] where he describes the methods used for obtaining fresh water in large ships. The treatment described is that of adding a surface active agent which will modify the normal crystal habit of the scale forming materials so that they become friable and break away from the surface. Belloid (sodium salt of di-naphthyl methane di-sulphonic acid) has proved a suitable material, and the addition of sequestrol is also valuable in dealing with the calcium, magnesium and copper salts. The result of adding these materials has meant that evaporators can be run for 4,000 hr. without stoppage for cleaning. The influence of the addition of anti-foaming compound, a polyethylene glycol, in very small quantities is also examined and some results are given.

Conclusion

During the past few years there have been some real attempts to provide new forms of equipment such as the *Turba-Film* unit and the unit made by Powell Duffryn. Some progress has also been made in considering the thermodynamic efficiency of evaporators particularly with the thermo-recompression system. We are, however, seriously lacking in fundamental knowledge of the process of boiling liquids on various surfaces particularly in the presence of any solid particles and without more information of this kind it is difficult to see in what way new techniques are likely to be developed. Thus even in the manufacture of salt we have few methods for controlling the size of crystals and we are undecided as to the most suitable method for avoiding, or minimizing, scale formation. Over the years there have been a number of attempts to introduce new materials of construction, particularly plastics and carbon, and an indication that higher velocities are probably worth paying for in modern conditions.

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Table 4. Data on Evaporator[6]

Day following cleaning	Steam to 1st calandria.	Evaporation rate lb./ft. H.S.	Without juice, electrolyser scale index				With juice, electrolyser scale index			
			1	2	3	4	1	2	3	4
1	10.1	9	100	100	100	100	100	100	100	100
2	12.6	8.9	74	102	93	102	86	107	103	91
4	17.8	8.7	45	88	93	100	75	107	100	97
7	22.7	8.9	35	90	92	95	59	100	100	90

Table 5. Data with Juice Electrolyser and Aluminium Sulphate[6]

Day following chemical treatment	Steam pressure, 1st cal. p.s.i.	Evaporation rate, lb./sq.ft.hr.	Scale index			
			1	2	3	4
1	12.5	9.4	100	100	100	100
2	11.5	8.4	90	98	84	94
4	14.2	9.1	85	93	88	98
7	16.6	9.0	85	89	82	94

Effluent Disposal Problems in the Chemical and Allied Industries

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Increasing attention is being paid to the disposal of trade effluent, but the chemical and allied industries are still faced with some big problems. In this article,* the author points to ways in which some of these problems might be approached, and gives a few illuminating examples of treating effluents by physical, chemical and biological means. Finally, he discusses briefly some points to be considered in locating and planning new plants.

UNTIL almost a century ago, it was apparently widely held that there was nothing improper or unsocial in disposing of unwanted material, whether solid or liquid, into the nearest stream. In fact some people attempted to justify such action by contending that nature had provided streams for the purpose of carrying away habitation and industrial wastes to that convenient and capacious receptacle—the sea. For reasons which to a later generation are self-evident, there gradually developed a more enlightened attitude to what may now conveniently be referred to as ' stream sanitation'.

During the past 50 years, great advances have been made in the treatment of sewage and industrial wastes. In retrospect it may seem that the chemical industry lagged considerably behind other industries in attempting to devise satisfactory effluent treatment processes. If this is correct, it may be attributable, in part, to the uniqueness of the industry's problems. However, much leeway has been made during the past 25 years or so, and particularly in the last decade. Many branches of the chemical industry now have officers and even research departments whose duties are concerned solely with the investigation of trade effluent problems. Moreover there are indications that such problems are being tackled because of a genuine appreciation that it is right that this should be done, and not merely because the law requires it.

Principles of trade effluent treatment

In dealing with any trade effluent problem, it is always well worth while making as complete a survey as possible of the nature and volumes of the various constituent liquids. As a result, it may be possible to direct attention to means of segregating or of avoiding the production of certain wastes. Some wastes may lend themselves to recirculation or re-use, and this might prove doubly attractive, firstly by reducing expenditure on overhead charges and secondly by reducing the volume of effluent to be treated. Better and more complete methods of separating the product being manufactured may be possible, thereby providing slightly increased yields, as well as reducing the effluent treatment problem. By-product recovery may be worth investigating, though sometimes such processes may introduce a new disposal problem.

Broadly, methods of treatment fall into three main classes: physical, chemical, and biological, with suitable combinations of these. Some of the processes may conveniently be adapted to continuous operation; with others it may be desirable or essential to adopt batch treatment.

Physical methods may be subdivided into screening or straining (*i.e.* mechanical removal of solid matter in suspension), and settlement, in which the supernatant liquor (possibly still containing non-settleable solids) and the sediment or sludge are subsequently dealt with separately.

If the suspended solids are putrescible, as for instance in wastes from food processing, it will usually be an advantage to remove them in as fresh a condition as possible, since fermentation or putrefaction will tend to increase the dissolved impurity and render subsequent purification more difficult.

Very fine screening is more usually referred to as mechanical filtration, which may be carried out at, above, or below atmospheric pressure. In both screening and mechanical filtration it is obvious that the success of the process will depend to a large extent on the facilities available for removing the accumulated solids, and if this can be done more or less continuously it will usually be a great advantage.

For treatment by settlement, several types of tanks are available, most of which are similar to those used in sewage treatment. Here again facilities for the frequent or continuous removal of settled solids or sludge are usually an advantage, but such facilities naturally increase the cost of the plant and may not be justified in small installations. In certain types of waste the solids in suspension do not settle readily, and sometimes much that appears to be in suspension is really in a colloidal condition, and coagulation may be a necessary preliminary. The addition of a suitable chemical reagent may bring about the formation of a flocculent precipitate which will entrain the finely dispersed solids and precipitate them. The chemicals most commonly used are lime, commercial aluminium sulphate, iron salts and sulphuric acid.

The efficiency of floc formation depends a great deal on the pH value of the liquid. For some coagulants the optimum pH range is narrow, for others it is wide and sometimes there is more than one effective range. When metallic salts are used for this purpose it may therefore be necessary to add acid or alkali to effect the necessary pH adjustment. Flocculation may in fact sometimes be brought about simply by neutralisation with acid or alkali.

In all cases it is essential that proper

Fig. I. General view of the biological purification plant at the Ruabon factory of Monsanto Chemicals Ltd.

control be kept in regard to the addition and intimate admixture of coagulant with the waste. The addition of unnecessarily large amounts of reagent will obviously be wasteful, but it must be emphasised that usually precipitation does not take place until a certain minimum amount of reagent has been added, and the addition of a smaller amount, even if only very slightly below the required minimum, would result in the waste of all the coagulant so added.

It sometimes happens that an industry produces two or more different types of waste liquid, and it may be an advantage to segregate them and mix them subsequently under controlled conditions. Occasionally a waste liquid which is sufficiently non-polluting to be discharged to stream untreated can be utilised in the treatment of other wastes.

Frequently, the most efficient and the cheapest method of purifying trade effluents which are amenable to decomposition by the activity of micro-organisms, is by biological processes similar to those used in the treatment of domestic sewage. One advantage of such processes is that standard equipment is usually available from manufacturers of sewage treatment machinery.

Some typical examples of effluent treatment are given in outline below.

Treatment of wastes from iron and steel pickling

The removal of scale from some iron and steel products—sheets, strip, wire, etc.—is brought about by im-

mersing the material for a short time in acid. Thus the oxide scale is dissolved. Gradually, because of the lowering of the acidity and the accumulation of dissolved salts, the pickling liquor loses its efficiency and has to be disposed of. Sulphuric and hydrochloric acids are those most commonly used, but nitric, hydrofluoric and phosphoric acids also find application. Sometimes a mixture of acids is used.

The waste pickle liquors ultimately to be dealt with consist, therefore, of a solution of ferrous salts containing free acid. They vary considerably in composition, but may contain from 0.5 to 5% of free acid and up to 40% of ferrous salts. Admixture of the waste pickle with wash waters will, of course, reduce these figures. Whether for complete treatment prior to discharge to stream, or for partial treatment prior to discharge to sewer, the liquor must be neutralised.

In one plant designed to give complete treatment, milk of lime is added to the waste, which after intimate mixing passes along a shallow channel in which are arranged diffusing devices fed with air from a compressor. The green ferrous hydroxide is rapidly oxidised to brown ferric hydroxide. The treated waste passes to a settling tank, the clarified supernatant liquor overflowing the final weir being discharged to stream, and the settled sludge conveyed to a large lagoon from which the consolidated sludge is periodically removed by grab and carted to a dump.

A much more satisfactory method of dealing with the sludge is by filter-

pressing. In some instances, especially where hydrochloric or nitric acid is used for pickling, the sludge-cake can be disposed of for use in "purifiers" for removing hydrogen sulphide from crude coal gas. (Calcium sulphate is not very soluble, and the ferric hydroxide from sulphuric acid pickling is thus contaminated with calcium sulphate and is less attractive for this purpose).

The neutralising agent commonly used is quicklime—that from dolomitic limestone has a higher basicity factor but is less reactive than high calcium limestone. Waste limes, e.g. from certain water treatment processes or from acetylene manufacture, are sometimes used, but a careful check should be made as to their suitability.

For partial treatment prior to discharge to sewer, some local authorities require neutralisation only. Others place a limit on the suspended solids content of the neutralised liquor. It should be remembered that calcium sulphate, which is produced in the neutralisation by lime of sulphuric acid pickles, is corrosive to concrete and sewage works structures.

The process just described for pickling liquors illustrates a method of treatment utilising physical and chemical agencies.

Sewage treatment processes

It is convenient in considering biological purification processes to refer to the general principles of sewage treatment.

After removal of grit and removal either by screening or disintegration of coarse suspended matter, the sewage is passed through a continuous flow settling tank. The settling tank effluent contains fine suspended matter, which does not settle easily, and almost all the soluble impurity present in the sewage.

The next stage is a biological one, use being made either of what is invariably but inappropriately known as biological filtration, or of one of the so-called activated sludge processes. In both systems, the conditions are such that the natural degradation and purification processes are greatly intensified and accelerated.

In the former the liquid is distributed at controlled rates over the surface of the " filter", a bed, usually 6-ft. deep, of hard, durable material, mainly of 1-in. to 3-in. grade, with still coarser material in the lowest layer, and preferably supported on special underdrains, since adequate ventilation of the bed is essential. By natural agencies, there gradually builds

up on the surfaces of the material forming the filter medium, an intensely active biological slime, composed of bacteria and other micro-organisms, with eventually a few macro forms (worms, larvae, etc.).

This biologically active material feeds on the organic impurities in the sewage, breaking them down in the presence of air carried into the filter, into simple inorganic material, ammonium salts, nitrites, nitrates, carbon dioxide, etc., which are not usually detrimental when discharged to a flowing stream. A residue, resembling soil humus, is also formed, and this is more or less continuously flushed out of the filter. Excessive amounts of this humus if discharged to stream would be detrimental, but it settles fairly readily and can conveniently be removed by passing the filter effluent through a final settling tank.

In the activated sludge process, the settled sewage is conveyed to a unit in which the liquid is vigorously agitated, either by diffused air or by mechanical devices, which continuously break up the surface of the liquid (surface aeration). A biologically active material, similar to that formed on percolating filters, is gradually built up, but in this process naturally flocculent solids, resembling the humus solids previously referred to, themselves provide the anchorage for the organisms which bring about the purifying process. Settled sewage is added continuously to the aeration tank, and a corresponding amount of purified effluent continuously withdrawn. After settlement, the clear supernatant is discharged to stream. Part of the settled sludge may be returned to the unit to maintain optimum biological activity, and the remainder run to waste.

Plant for treating phenolic wastes

It does not surprise us that sewage matter provides food material for the proliferation of micro-organisms, or that the end products of their activities should be relatively harmless. Yet what we should consider poisonous substances like phenols and their derivatives, formaldehyde and even cyanide, can be broken down by similar biological action to that just described, either alone or in admixture with domestic sewage, and provided the concentrations of the substances concerned are not too great. Thus a solution containing a few per cent. of phenol in water has disinfectant properties, whereas a solution containing up to 0.02% of phenol can be readily decomposed by micro-organisms.

The factory of one large chemical concern produces a variety of organic chemicals, the most important being synthetic phenol, salicylic acid, aspirin, phenacetin, phthalic anhydride and esters, benzoic acid, many chemicals used in rubber processing and several disinfectants and weed-killers. The factory is situated on a salmon river.[1] Formerly soakaway pits were used for disposing of the effluent, but expanding production made it necessary to devise a more certain method of disposal.

Discharge of the effluent to the local sewerage system was impracticable, since the normal flow of sewage was little more than 10% of the volume of the wastes produced at the factory, but following extended laboratory and pilot plant investigations, a treatment plant, very similar to a sewage treatment plant using biological filters, was constructed.

Briefly, the strong and weak liquors first pass to separate storage and balancing tanks to facilitate equalisation of composition and flow of the mixed wastes. The pH value is then adjusted by automatically controlled addition of lime slurry to between 6 and 8, the optimum range for subsequent biological treatment, and the waste passes to a radial-flow settling tank. The clarified liquid is then distributed uniformly over the surface of percolating beds, the discharge from which flows to a secondary settling tank, the overflow from which may be passed to the river either direct or by way of storage ponds, which enable the rate of discharge to be adjusted to suit river conditions. Provision is also made for recirculating clarified effluent, a process which for several reasons increases the efficiency of the biological breakdown of the organic materials present in the waste.

Sludge from the clarification processes is coagulated with lime and ferric chloride and dried on sand beds. The dried sludge is inoffensive, and has proved of value in horticulture. It is humus-like in texture and contains about 6% of nitrogen and 1.4% of phosphorus (as P_2O_5).

The plant is extensively instrumented, including integrating flow recorders, temperature recorders, signal lamps and audible alarms, and the entire plant is operated under strict and continuous laboratory control. A general view of the plant appears in Fig. 1.

Extensive chemical and bacteriological research has been undertaken, including isolation and characterisation of the organisms responsible for the biological breakdown of the organic

substances, and it has also been shown that the wastes are amenable to treatment by the activated sludge process, as well as by the use of percolating beds.

The project provides an outstanding example of a genuine aim to ensure that industrial activities shall not impair the community's enjoyment of the amenities of the river concerned.

Treatment of a strongly bactericidal waste

An account has recently been given[2] of a plant for giving complete treatment to an even more intractable liquid than that just described. Fig. 2 shows a simplified flowsheet of this plant. The waste waters are derived from the manufacture of pesticides, insecticides and fungicides, and probably contain dinitro-ortho-cresol (DNOC), dinitro-secondary butyl phenol (DNBP), 2-methyl-4-chlorphenoxy-acetic acid (MCPA), dichlorodiethyl-trichlorethane (DDT), copper salts, phenol and cresol with various of their sulphono-, chloro-, and nitro-derivatives, solvents, surface active agents, glycollic acid, amine salts, and sodium sulphate and chloride—a formidable enough mixture for partial chemical analysis, let alone for treatment to produce a non-polluting effluent.

As would be expected, biological treatment as commonly used showed little promise of success. Resort was therefore had to preliminary treatment with activated charcoal, using percolation through beds of granular charcoal, which process for several reasons proved to be preferable to stirring with powdered carbon. This section of the plant consists of three mild-steel adsorption towers and three rubber-lined towers to permit sorption under acid conditions. The use of three towers permits continuous operation using two towers in series.

Before charcoal treatment, the pH of the waste is at present adjusted to 7.5, though it is intended later to work at pH 3. On leaving the towers the effluent is mixed with lime slurry to precipitate copper salts. The clarified effluent is then neutralised with sulphuric acid and passes to storage and balancing tanks.

In the next stage the liquid is first mixed with river water and with either settled domestic sewage from the works or a commercial biological additive, and is then conveyed to percolating filters, which may be operated to give single filtration, recirculation, or double filtration with periodic change in the order of the

filters. The filter effluent passes to a two-compartment tank, in the first compartment of which it is aerated. Final settlement takes place in the second compartment, prior to discharge of the effluent to the river.

The charcoal after use in the towers is reactivated at a minimum of 750°C., at which temperature adsorbed organic compounds are effectively oxidised and atmospheric pollution prevented.

Metal plating wastes

Compared with many other wastes from chemical and allied industries, the relative volume of plating wastes is small, but their disposal can be extremely troublesome, because of the intensely toxic character of the constituents, which may include acids (from stripping baths), salts of metals such as copper, zinc, nickel, chromium and cadmium, and in particular cyanides. Waste liquid containing cyanide may also be derived from case-hardening processes in which the metal is immersed in a bath of molten sodium cyanide, and subsequently quenched. Water after use for this latter purpose has been found to contain as much as 250 p.p.m. of cyanide, which substance may be toxic to fish at concentrations of less than 0.1 p.p.m.

In dealing with waste waters from plating and related processes, time spent on a full survey, with attention to possible means of limiting the loss of liquid carried over on the article from the stripping or plating processes, is well worth while. Wastes containing cyanides should be isolated as completely as possible and dealt with separately.

With the other wastes, neutralisation of acidity and removal of heavy metals is the aim. Generally, with the exception of chromate ions, raising the pH to 8 will effect the precipitation of the metals as hydrous oxides, though if the total amount of these is relatively low, the addition of aluminium sulphate will assist in flocculation. Chromate or dichromate ions must first be reduced to chromium salts. This can conveniently be done by the use of ferrous sulphate, preferably using twice the stoichiometric equivalent, thus accelerating the reduction. Apparently the pH value is not very critical up to about 10, but after reduction it is adjusted to 8. Sulphur dioxide has also been used as a reducing agent. The processes do not lend themselves readily to continuous flow and should be arranged for batch treatment.

Removal of cyanide from waste waters

Two processes have been commonly used for removing cyanide from waste waters. In the first of these, the liquid, after being made alkaline (pH 8 to 10) by addition of lime, is treated with ferrous sulphate to produce an insoluble complex iron cyanide which can be removed by settlement or filtration. It is not usually possible by this means to reduce the cyanide concentration to below about 5 p.p.m. The process is suitable for use with sodium, cadmium, and zinc cyanides, but is less satisfactory when copper is present and of little use when nickel is present. In spite of these limitations, it may be useful as a partial treatment prior to discharge to sewer. Both lime and ferrous sulphate are cheap, and a marked excess of either is not particularly detrimental.

When virtual elimination of cyanide from waste waters is necessary, one of the best methods of treatment is chlorination at pH values over 11.0. Either hypochlorite or gaseous chlorine may be used, the basic reaction being:

$$HCN + Cl_2 \rightarrow CNCl + HCl$$

and this is complete as soon as free chlorine can be detected, e.g. by starch-iodide paper. Fortunately, as cyanogen chloride is even more toxic
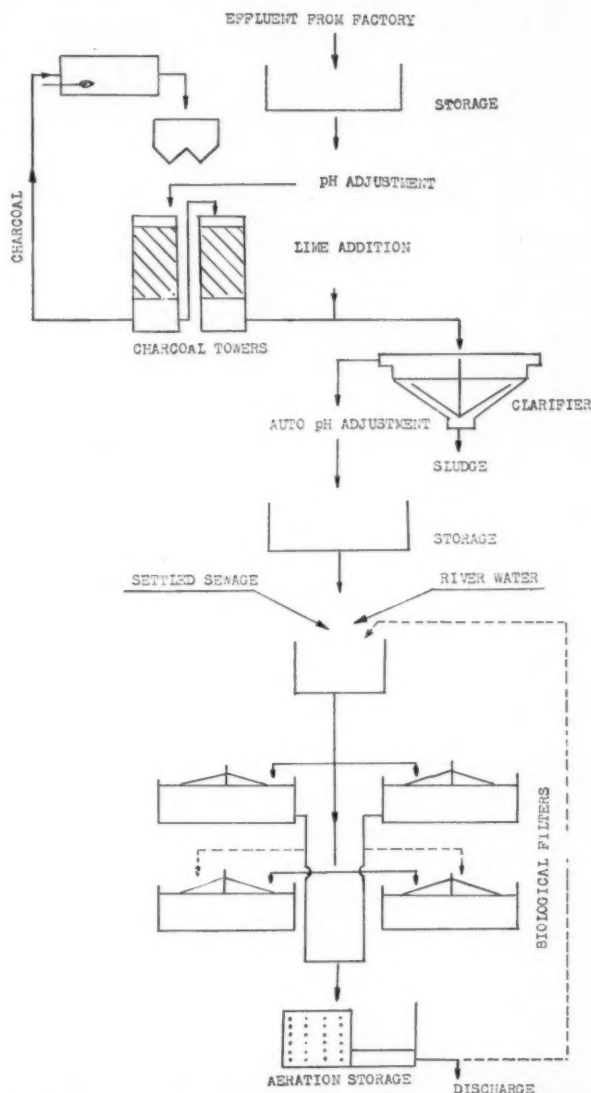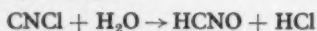

Fig. 2. Flow sheet of plant for treating strongly bactericidal waste.

than cyanide, hydrolysis of the former compound proceeds concurrently at this pH to cyanate

$$CNCl + H_2O \rightarrow HCNO + HCl$$

which is not toxic. If the chlorine is not present in sufficient excess, and if the pH falls below about 9, the hydrolysis proceeds very slowly.

Complex cyanides of zinc, cadmium and copper react similarly, the latter giving a cupric salt. Nickelocyanide is not completely attacked, and nickel-containing wastes should accordingly not be allowed to mix with the wastes containing cyanide.

If the effluent is to be discharged to stream, overdosing with chlorine must be avoided, and this is best achieved by batch treatment of the wastes, any residual chlorine being removed by addition of thiosulphate, and the pH finally adjusted to not more than 8 before discharge.

It has been known for some years that concentrations of 2 to 5 p.p.m. cyanide in sewage do not seriously interfere with the normal sewage treatment processes. Recent work at the Water Pollution Research Laboratory has shown the possibility of separately treating cyanide wastes containing up to at least 100 parts per million of cyanide in percolating filters, similar to those used in sewage treatment.[3, 4]

The use of potassium permanganate for oxidising cyanides has also been described recently.[5]

Ion-exchange materials in effluent treatment

Ion exchange, as a unit chemical process, has been defined as a process in which there is a reversible interchange of ions between a liquid and a solid, involving no radical change in the structure of the solid. The simplest example is the base exchange (cationic exchange) method of softening water, using natural or artificial zeolites, the reaction being commonly represented as follows:—

$$2NaZe + Ca^{++} \rightleftharpoons CaZe_2 + 2Na^+$$
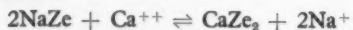
In the water-softening stage, the process proceeds from left to right, calcium and magnesium ions in the water being replaced by equivalent amounts of sodium ions. When the sodium zeolite has been exhausted, it is regenerated by treatment with a strong solution of common salt, the reaction then being in the direction right to left, the regeneration waste consisting of a solution of calcium chloride. Such ion-exchange materials can only be used over a comparatively restricted pH range (6 to 8.5), as they are not stable to acids and alkalis.

Synthetic organic ion-exchange materials have now been developed which are insoluble in aqueous and organic solvents, are stable to acids and alkalis, and also to oxidising and reducing agents. Such materials have already found a very wide range of applications both in the elimination of unwanted constituents and the isolation of useful ones. The processes obviously lend themselves to effluent treatment, and in some instances are particularly attractive in that they offer means of recovery of useful constituents which would otherwise have to be discarded.

One application that has been described is for the reactivation of anodic and chrome plating liquors.[6] In this, recirculation of part of the chromic acid anodic vat liquor through a hydrogen-ion exchange unit effects the removal of aluminium, copper, iron and tri-valent chromium, as well as other impurities. For chrome plating vat liquor, the chromic acid content of which is much greater than in anodic vat liquor (10% for the latter as against 25% for the former), part of the vat liquor, after withdrawal, is first diluted to $12\frac{1}{2}\%$ chromic acid and then passed through the exchange unit. It is then returned to the vat, either after the addition of chromic acid to restore the initial strength, or after concentration by evaporation.

Phosphoric acid pickling liquor can be reactivated similarly, as like chromic acid, phosphoric acid is a fairly weak acid to which the exchange resin is fairly stable. The process also finds application in the removal of metal salts, simple cyanide, etc. from waste wash waters.

Favourable results have been reported in the use of ion-exchange material for the removal of thio-cyanates and thiosulphates from coke oven effluent. The effluent after being so treated is passed through beds of active carbon for removal of phenols. This latter process alone has seldom proved successful because other adsorbed materials are not removed satisfactorily during regeneration of the active carbon. It may be that the life of the carbon will be greatly increased by removal of such constituents at an earlier stage. A plant operating on this principle has recently been installed at the new Avenue carbonisation works of the National Coal Board, and the results obtained with it will be watched with interest.

There seems no doubt that ion-exchange processes will receive considerable attention, and that new and improved exchange materials will be developed. It must not be overlooked, however, that like so many other processes, they serve to concentrate the materials being eliminated, as distinct from converting them by chemical or biological breakdown into less harmful substances. This may not, of course, prove to be a disadvantage, since there can be no doubt that vast quantities of potentially useful materials have been and are being wasted, instead of being recovered. Such wastage is neither in the best interests of the industry nor of the community.

Location and advance planning for new industrial developments

The location of many existing industrial concerns, including two of those to which reference has been made, has been very largely fortuitous. This fact has often made effluent disposal more difficult than it might otherwise have been. It will be obvious that whenever development is being considered, adequate and sufficiently early consideration should be given to the disposal of industrial effluents.

Many important factors have to be taken into account in locating new industries, and trade effluent disposal must be one of them, if the best use is to be made of past experience and avoidable difficulties are not to be encountered. Quite often a cheap site has been the prime consideration, and cases have been known where not until a factory was in course of erection had it been found that no means were available for disposing of the effluent. It has been pointed out that it might be better to pay £2,000 per acre for land where facilities exist for discharge of effluent to sewer, than £50 an acre where there were no such facilities.

Sometimes the segregation of wastes may facilitate treatment and sometimes pumping costs or expensive excavation can be avoided by adjusting the level of certain units so that they will discharge by gravity to the optimum drainage levels inside and outside the factory. Those who may be concerned with such problems would be well advised to study a paper by Cremer and Fitt[7] which gives some guidance.

New industries having difficult effluent problems are, not unnaturally, eager to seek sites on estuarial and tidal waters. While, because of increased dilution, the extent of the problem may be lessened, it must not be thought that it is necessarily eliminated.

Chlorine Manufacture in France

Despite some severe handicaps, the French chlorine industry has been steadily raising its output. This article, after giving a brief glimpse of early chlorine-manufacturing activities in France, shows how far the industry has gone in carrying out its plans for modernisation and expansion.

Birth of the French chlorine industry

SINCE 1789, when the great French chemist Berthollet, in an important paper, treated chlorine as a compound of muriatic acid (*i.e.* hydrochloric acid) and oxygen, enormous progress has been made with regard to our knowledge of the chemistry of chlorine. Twenty years after that date it was already obvious that Berthollet's conception of chlorine as oxymuriatic acid, which was shared by all the scientists of his time, was wrong, and chlorine was recognised as an element.

But this error of interpretation by no means detracts from the value of Berthollet's experiments. In this connection it might be interesting to quote a passage from the paper in question, dealing with a liquid which ever since that time has been known in all French households as 'l'Eau de Javel':

" Soon after I had started my research, I was asked to go to Javelle and show the manufacturers the method of making oxymuriatic acid and using it for bleaching purposes. I did not hesitate to comply with this request, as I wanted the method to become known. Some time later they published in several periodicals their discovery of a liquid which they called 'Javelle lye' and which had the property of bleaching linen, if it was immersed in the liquid for some hours. They had altered the method which I had demonstrated to them, by passing the gas not into pure water but into an alkaline solution. In this way they obtained a much more concentrated solution and could use the gas to make immediately several quantities of the bleaching liquid. ...."

The French chlorine industry could develop only after the electrolysis of sodium chloride had replaced the older methods of making chlorine from hydrochloric acid. Sir Humphry Davy at the beginning of the 19th century had been the first to obtain chlorine by electrolysis, but it took a hundred years before this method was used in the industry, and in France the large-scale manufacture of chlorine started in 1914, when the gas was required for war purposes. When the war was over, the demand dropped suddenly,

Electrolysis of sodium chloride at the Saint-Auban works.

and the manufacturers were very anxious to find new outlets for the production in addition to the quantity required for making l'Eau de Javel. On the whole the French chlorine industry remained stationary between the two world wars, and in 1938 the annual production amounted to 47,000 tons.

Location of chlorine works

Twenty-two works in France are busy making chlorine or chlorine compounds. There is a distinct localisation of the industry in certain areas. About 75% of the works are situated in the provinces of Savoy and Isère—the two important centres for the bleaching of oil—particularly in the two main valleys of the Tarentaise and the Maurienne and to a lesser degree in the valleys of the Doron and the Romanche. Other works are situated in the provinces Vaucluse and Haute-Garonne, amongst them the very important Beyrède works.

The manufacture of chlorates is even more concentrated, Savoy being the only province where chlorates are made. At Pomblières near Moutiers in the Tarentaise district sodium chloride is electrolysed to obtain liquid chlorine, sodium for laboratory pur-

poses, chlorates, caustic soda and various hypochlorites. Local salt mines supply the raw material.

In the Arc valley in the Maurienne district the main electro-chemical industry is the manufacture of aluminium and of alloy steels, but the electrolysis of sodium chloride has now become established as an important side line. The Prémont works situated between Modane and Saint-Jean de Maurienne make sodium metal by the electrolysis of molten sodium chloride.

There are three important chlorine works in the Romanche valley: at Pont-de-Claix, where the Romanche flows into the Drac, at Jarrie and at Pierre-Eybesse. The first two works use sea salt, which they get from Languedoc. They can afford to pay the freight as the value of their products is relatively high. Both works confine their operations to the first stage of manufacture, whilst pure sodium is extracted at Pierre-Eybesse. Pont-de-Claix is better placed for receiving the salt because it is situated near the Dauphiné plain. Its programme of manufacture is comprehensive and includes solvents, decolorising agents based on chlorine and organic chlorine compounds such as methyl chloride and monochloroacetic acid,

the raw material for the manufacture of synthetic indigo.

The list would not be complete without mentioning the aluminium works of Saint-Auban on the Durance, which electrolyse sodium chloride and make gaseous and liquid chlorine as well as organic chlorine compounds. There is also an old war factory at Saint-Jean-de-la-Riviere on the Vésubie, which was built in 1918 and has continued its manufacture of liquid chlorine ever since.

Production creeping up

Chlorine plays an important part in world economy, particularly since 1945. Chlorine is used in many industries such as textiles, fuels, plastics, leather, paper, hygiene, bleaching, explosives, war gases, anaesthetics, chemicals for use in agriculture, dyestuffs, paints, varnishes etc. To give an idea of the economic importance of chlorine and its derivatives it will be sufficient to mention that the American production of chlorine has increased since 1921 from 67,000 tons to 4 million tons p.a. French production figures do not show an increase of the same order:

1948	66,510 tons
1949	70,331 tons
1950	81,679 tons
1951	102,320 tons
1952	106,362 tons
1953	113,666 tons
1954	140,000 tons
1955	180,000 tons

As these figures show, the production of chlorine has increased rather slowly in France. In fact the manufacture of chlorine is one of those branches of industry which have suffered most from wartime restrictions with regard to modernising the equipment and increasing the consumption of electricity (4,500 kw. are required to produce 1 ton of chlorine). Important increases of production have therefore only been possible since 1952.

Modernisation and expansion

An official report on the modernisation and re-equipment required in the chlorine industry pointed to the need for an increase in the production capacity from 75,000 tons in 1948 to 150,000 tons in 1952-53 and for a modernisation of plants producing 25,000 to 30,000 tons p.a. of chlorine. During 1950 three new plants with a total capacity of 18,500 tons were put in operation: one of 11,000 tons at Pont-de-Claix (Isère) by the Société Progil, another of 2,500 tons at Lamotte-Breuil (Oise) by the Société Bozel-Malétra and a third plant of 5,000 tons at Tavaux (Jura) by the Société Solvay. Further plants, bringing the total capacity up to 88,600 tons, have been in course of construction since 1951. The most important of these are those of Pechiney at Saint-Auban (Basses Alpes) and Société Potasse & Produits Chimiques at Thann (Haut-Rhin).

In 1951 plants with a capacity of 24,000 tons were put in operation, and in 1952 the expansion of the production capacity amounted to 20,000 tons, 13,000 tons being accounted for by the Société Progil at Pont-de-Claix (Isère), 4,000 tons by the Société Bozel-Malétra at Lamotte-Breuil (Oise) and 3,000 tons by the Société Solvay at Tavaux (Jura). In 1953 the capacity increased by 17,500 tons bringing the total capacity up to 145,000 tons. Since then there has been a further substantial increase, and at present the total capacity amounts to about 200,000 tons p.a.

The industry's future

There is no doubt that the uses of chlorine will develop during the next few years. Adjusting production to the required level will be made easy by the very structure of this industry, which consumes over 75% of its own production.

However, the future of the French chlorine industry depends first of all on the cost of electricity. In spite of certain special reductions this cost remains too high. The same can be said of the price of salt or, to be more accurate, of the freight charges which increase the price of the salt. Two tons of salt are required to make one ton of chlorine, and the chlorine works situated in the Alps are rather far away from the salt works at Marseilles.

These, then, are the main preoccupations of the French chlorine industry. To overcome one of the main problems—the high price paid for salt—it may be that certain firms will consider the erection of chlorine plants in the neighbourhood of Marseilles. On the other hand, the solution may well lie in the replacing of the present electrolytic process with one which does not depend on electricity; numerous investigations of this problem are in progress.

Detergent Alkylate Plant in Production

The £1-million Grangemouth plant of Grange Chemicals Ltd. is now in production. It is producing detergent alkylate of very high quality at design output, which is in excess of 10,000 tons p.a.

The plant receives its main raw material, propylene tetramer, from British Hydrocarbon Chemicals Ltd.,

and by reaction with indigenous benzene converts it to dodecyl benzene, the main active constituent of most domestic synthetic detergent powders

Until the commissioning of the Grange Chemicals plant there was only one U.K. source of this raw material, which was insufficient for the country's requirements. With the capacity of this plant, imports will no longer be necessary and by mid-1956 it is expected that an exportable surplus will be available, particularly to those countries in the sterling block which now have difficulty in finding dollars for this raw material.

Propylene tetramer is made in the adjoining Grangemouth petroleum refinery from the polymerisation of propylene and will also be made in the new "tetramer plant" being erected by British Hydrocarbon Chemicals. These two sources will satisfy the requirements of the Grange detergent alkylate plant and provide in addition a surplus of propylene tetramer for sale through Grange Chemicals.

Grange Chemicals Ltd. was formed in 1955 as a joint undertaking of British Hydrocarbon Chemicals Ltd. (formerly British Petroleum Chemicals Ltd.) and the Oronite Chemical Co. of San Francisco.

Explosions, Poisons, and the Chemical Engineer

By J. H. F. Smith, M.SC., F.R.I.C., A.M.I.CHEM.E.

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The author, one of H.M. Inspectors of Factories, was afforded the opportunity by the Rockerfeller Foundation of spending three months in the United States for the purpose of studying the chemical and chemical engineering aspects of industrial safety and health. In a paper presented to the Institution of Chemical Engineers in London in January, he compared some of the American precautions against explosion, gassing, poisoning and other hazards with those used in Britain. Some extracts from this paper appear below.

IN the American approach to industrial safety, there are surprising similarities to British methods and at the same time some outstanding differences. In Britain we have built up during the last 150 years an elaborate system of factory law administered by inspectors employed by the central government. In America, with 48 states each making its own laws, there is little consistency between the laws of one state and another. It seems that a combination of our legal system and some of the American methods for the education of both management and men in safety and health matters might be beneficial to both countries.

In Britain we have not done very much so far to teach the ordinary workman the dangers of the materials and plant with which he is concerned and the reasons that lie behind precautions to prevent injury or poisoning. We ought to do more, and we can learn a great deal from American authorities and from some of the big American companies.

We should not, however—and this is where the work of the chemical engineer is important—design and build plants which are unnecessarily dangerous and then expect men to operate them safely by 'education.' When a plant is designed the designer should ask himself:

(1) What dangers can arise if the plant operator does something wrong or omits some necessary task.

(2) What dangers can arise through failure of controls, of electricity, of cooling water, etc.

(3) What steps can reasonably be taken to deal automatically with these dangers or to limit their effects.

Designing plants for safety

In the design of any chemical plant, consideration should be given to the need for interlocks and pressure reliefs at every point where energy can enter the system or be generated in the system.

Isolating valves between stills and condensers are almost always unnecessary and they should be eliminated. Isolating valves in pressure relief lines are also best eliminated, but if they are necessary, duplicate pressure relief systems suitably interlocked should be provided.

The Americans gave a lead 20 years ago in the provision of automatic safety devices to prevent explosions in ovens, furnaces and other plant heated by gas or oil. They still seem to be ahead of us in this respect. Flame electrode and, for small plant, theremocouple types of automatic pilot were seen to be widely used as safeguards against ignition failure and flame failure in gas-fired equipment, and apparently the photo-electric cell device is becoming the standard type of safety control for oil-fired plant.

Cooling water and airflow interlocks seemed to be fairly common, but it was noticed that, as in Britain, engineers in the U.S. sometimes make use of pressure-operated switches for these interlocks. Such safety devices fail dangerously if there is a blockage or a closed valve or damper downstream of the device, because pressure can then be maintained without flow. Devices actuated by flow rather than by static pressure are obviously preferable. Alternatively, in the case of condenser water, devices reacting to temperature are often used.

Several American companies make fixed multi-point explosimeters which analyse continuously the solvent vapour concentrations inside various parts of a plant and in workrooms. They operate alarms and controls if a concentration is abnormally high.

Widespread use of small portable explosimeters to check concentrations of inflammable gas and vapour was observed. These are usually calibrated in percentages of the lower inflammable limit and most of them work on the principle of the Wheatstone bridge. One popular American type of explosimeter has a thermocouple to measure the increase in temperature of the wire instead of the Wheatstone bridge for measuring the alteration in resistance.

Commercial development and manufacture in Great Britain of fixed multipoint explosimeters and of portable explosimeters has lagged behind that in America and a number of British organisations have had to import American equipment. The position is rather better now and the Factory Department has asked the Fire Research Station at Boreham Wood to examine and report on the accuracy and efficiency of the explosimeters available in the country.

Explosion reliefs and flame arrestors

The vacuum and pressure impregnation process was seen in use in several American factories. In every instance nitrogen had been substituted for compressed air and in one factory the nitrogen was pumped away after use, stored and re-used.

Many industrial explosion risks due to inflammable gases and vapours can be reduced by diluting below the lower inflammable limit with air, by adding inert gas, by excluding air or, in some

special cases, by the method suggested by Elwyn Jones by adding a proportion of an inflammable gas or vapour with a narrower range of inflammability. All these methods are apt to break down occasionally and, consequently, auxiliary precautions to limit the spread and effects of an explosion are necessary.

It was noted that the Americans wisely pay more attention to the explosion venting of buildings and workrooms than is the case in Britain, but their practice, which was fairly common, of making the doors of ovens serve as explosion reliefs seems to be quite wrong. Doors of ovens, blown open violently by explosions or blown off their hinges, have frequently caused death or injury. They should therefore be provided with strong hinges and fastenings and the explosion reliefs should be fitted to vent in safe directions away from workpeople, *e.g.* in the tops and backs of the ovens.

Work has been carried out in the U.S. on flame arrestors, and the Bureau of Mines has investigated flame speeds in relation to flame arrestors, but apparently no fundamental study of the mode of action of flame arrestors has been made which would enable a designer to predict the performance of a particular type.

Experimental data on tubular and corrugated metal flame arrestors and on pebble-box types are available, however, and give some guidance.

Part of an experimental study of the subject of flame arrestors to be carried out in Britain will probably be an investigation of the conditions in which gas or vapour mixtures with air in ducts and pipelines can detonate.

Storing and handling inflammable liquids

Two kinds of precautions used in American factories where inflammable liquids are handled include, firstly, the almost universal use of non-spill portable containers for inflammable liquids and, secondly, the provision made in some workrooms to limit the spread of inflammable liquid to lower floors or to other workrooms should a big leakage or spillage of inflammable liquid occur. This was accomplished by sills, ramps at doorways and, in one case, by a special drainage system to a tank outside.

The problem of the size limit and of the positioning of vessels containing large quantities of volatile highly inflammable, or poisonous, material is very difficult. The manager of one American factory described a leakage that developed in a tank containing phosgene and how people were gassed in nearby houses. Similarly, in Britain, a leak occurred in a big tank storing liquid chlorine. Fortunately the tank did not contain much chlorine at the time and, by using the chlorine as rapidly as possible in the factory processes, it was possible to control the leakage.

It is preferable to use two or more small tanks rather than one large tank to store propane, chlorine, etc., because if trouble occurs at one tank or at its fittings there is a chance that its contents may be safely transferred to another tank. Better still is the provision of a spare tank, which is easier if the stock is contained in a number of small tanks.

Development work is taking place both in America and Britain on an ingenious system of explosion prevention which originated in Britain. A system of explosion suppression* based on the device has been developed commercially and has been installed in a number of factory plants, mainly as a precaution against dust explosions.

Industrial hygiene and the chemical engineer

There is a comparatively new profession in the U.S. which is virtually non-existent in Britain. Known as industrial hygiene, it has been defined as the recognition, evaluation and control of the causes and sources of diseases occurring characteristically in industry, and the preservation of the health and well-being of those engaged in industry. Many industrial hygienists are chemical engineers who have had post-graduate training in government service, in industry, in insurance companies, or at university schools. Most large companies now seem to employ industrial hygienists in addition to safety inspectors.

There is much that the chemical engineer can do to improve industrial hygiene and safety, especially in the prevention of poisoning and in the prevention of injuries due to corrosive chemicals.

The Americans, when pumping corrosive chemicals through pipelines, seemed to make more use of protective covers and enclosures for pipe flanges and valves than we do. In this country the spray or squirt of, for example, sulphuric acid, which occurs when a gasket fails or a leak develops for some other reason causes a considerable number of injuries, some of them serious. Several American factories were visited in which the pipe flanges

*See CHEMICAL & PROCESS ENGINEERING, 1955, **36** (9), 319; and (10), 365.

and valves were enclosed in specially made jackets of polyvinyl chloride or polythene. In these factories, incidentally, excellent protective clothing was provided and the workpeople seemed to be sufficiently well instructed to make good use of it.

Prevention of industrial poisoning is essentially the prevention of contact between harmful chemicals and men. The U.S. Department of Labor states that there are eight principal methods for the elimination or control of industrial health hazards, namely:

(*a*) Substitution of less toxic material.
(*b*) Enclosure of the harmful process (with automatic operation).
(*c*) Isolation of the harmful process from the remainder of the plant with special protection for workers necessarily included in the area isolated.
(*d*) Local exhaust ventilation.
(*e*) General ventilation.
(*f*) The use of wet methods.
(*g*) The use of personal protective devices, particularly respiratory protection.
(*h*) Decreasing the daily exposure through short work periods.

It is pointed out that one method by itself is often inadequate and that several may have to be used in combination. Chemical engineers who rely to any great extent on methods (*e*), (*g*) or (*h*) are generally making a confession of failure. Substitution of less dangerous materials for highly toxic, corrosive or inflammable materials is primarily the responsibility of the chemists, but they often need a little prodding from chemical engineers.

Complete enclosure of a process is generally possible, particularly if it can be made a continuous process. All too often, however, in British factories where for one reason or another the process is carried out in more or less closed plant, the feed and discharge ends are forgotten-until they are found by sad experience to be sources of dust or fume. Ventilation hoods, often of poor design, are then hastily constructed and added to the plant. Complete enclosure of feed, process and delivery is the ideal, and 'fume cupboard' enclosure of feed and delivery is much nearer the ideal than is the conventional hood. We should not forget to provide facilities for the maintenance men to do their jobs without unnecessary exposure to the chemicals or to the fumes and dust produced in the processes. Similarly, the laboratory assistants should be able to obtain the necessary check samples from the plant without risk of being gassed or being splashed with

acid, alkali, phenol and other chemicals.

American practice was seen to vary considerably, but there seemed to be a more general appreciation of how to trap dusts and fumes at source than is the case over here. Examples were seen in a few American factories of attempts to incorporate the feed part of the plant as a part of the enclosed process, for example, by direct connections between the discharge opening of a hopper on a rail waggon containing a siliceous powder to a storage hopper and then to the enclosed mixing vessels of a plant, or by having solutions instead of powder delivered so that transfer operations could be by enclosed pumping methods instead of by the handling of a dusty material in the preliminary stages of the process. Transfer of dangerous powders as a slurry is, of course, a method which has been used in this country, both to avoid leakages of dust which may be harmful to health and also to avoid risks of dust explosions.

These are isolated examples. What is needed is the development of industrial hygiene engineering on a systematic basis, possibly on a basis of unit operations. Transfer operations, crushing and grinding, size separation, filtration, mixing, drying, crystallisation, distillation, and extraction can all be done without contact between harmful chemicals and men, and also without danger to men from explosions, but not if the wrong methods are used.

Walker, Lewis and McAdams are said to have introduced the unit operations idea to chemical engineering. Can British chemical engineers show the Americans how to develop the safety and health aspects of chemical engineering into some similar well-defined order?

Effluent Disposal Problems in the Chemical and Allied Industries

There is an ever-increasing need for conserving Britain's water resources, and this may require, among other things, higher standards of purification of sewage and industrial effluents. It is in any event now generally recognised that pollution of rivers and streams is indefensible. It would none the less be foolish not to recognise that the country's prosperity cannot be divorced from the reasonable requirements of its industries. Not all effluent treatment problems can be solved simply, particularly in the chemical and allied industries. Nevertheless they must be tackled with the will to solve them, and the examples quoted provide instances where this has been and is being done.

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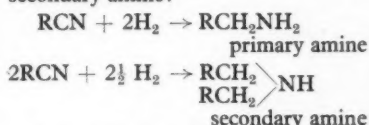[7] H. W. Cremer, and R. L. Fitt, Proc. Chem. Engng. Gr. Soc. Chem. Ind., 1945, 27, p. 52.

New British Plant makes Chemicals from Fatty Acids

A RANGE of cationic and nonionic chemicals, developed and pioneered in America, will be produced in a plant which has started operation in Littleborough, near Rochdale, Lancs. The plant, the first in Europe to produce these chemicals, was designed and constructed in England to plans of Armour & Co., Chicago, and is operated by Hess Products Ltd.

Amongst the chemicals produced are the *Armeens* (primary, secondary, and tertiary aliphatic amines) used in the textile and petroleum industries, for pigment treatment, and in surface coatings, for inhibition of corrosion including boiler water systems, in the preparation of quaternary compounds, and for other purposes. The *Armacs* (water soluble amines) are used as flotation agents for potash, phosphate, titanium, zinc, lead, and other ores; in wax and polish formulations, and wherever cationic emulsifiers and solubilisers are required. The *Duomeens* (aliphatic diamines) are used as anti-stripping agents in road-making and other applications of bitumen and tar, in moisture-proofing of masonry, in the curing of epoxy-type resins, in the metal working industry, in primer paints. etc. *Arquads* (water or oil soluble quaternaries) are used in textile and laundry applications, as anti-statics for resins and fabrics, in the paper and rubber industries, etc., Armour & Co. Ltd. are in charge of U.K. sales and exports.

The production process of these chemicals is extremely interesting to the fat chemist and the chemical engineer. The basic raw materials are fatty acids derived from tallow, coconut and other vegetable oils. After a fine fractionation of the fatty acids into pure compounds and their blending according to needs, they are fed in a continuous stream into the nitrile conversion reactors, which are the heart of the process.

In these catalyst reactors the fatty acids are brought into intimate contact with anhydrous ammonia. The overall formula of the reaction can be written:

$$R\ COOH + NH_3 \rightarrow RCN + 2H_2O$$

where R represents a fatty acid radical. The water formed during the reaction is removed. The resultant nitrile is then hydrogenated in specially designed convertors to give a primary or secondary amine:

$$RCN + 2H_2 \rightarrow RCH_2NH_2$$
primary amine

$$2RCN + 2\tfrac{1}{2}\ H_2 \rightarrow \genfrac{}{}{0pt}{}{RCH_2}{RCH_2}\Big\rangle NH$$
secondary amine

The primary amines form the basis for many of the other products, such as *Duomeens*, $RNH.\ C_3H_6NH_2$; tertiary amines, $R(CH_3)_2N$; and quaternary amine compounds.

The finished products are stored in tanks for delivery in road tankers or in drums.

The plant is laid out on the "straight line" principle in accordance with most modern and economical conceptions of chemical engineering. The crude fats enter one end of the plant. The finished materials issue at the opposite end, where there are ample storage and loading facilities. The boiler house is placed centrally and *Dowtherm* units are located at two points where high temperatures are required.

The processing plant is housed outdoors with the exception of the *Dowtherm* boilers, pumps, and instrument panels, which are under cover. Full use has been made of automatic control. The fatty acid fractionation still and nitrile units are controlled automatically and only one shift operator is required for each.

Amongst ancillaries on the site are a water circulation system, fed from a canal along the site; a research and control laboratory, and a workshop.

Aerial view of the T.V.A. experimental fertiliser plant, with Wilson Dam in the background.

New Fertiliser Processes in the U.S.

CHEMICAL ENGINEERING WORK BY THE TENNESSEE VALLEY AUTHORITY

Chemical engineering research and development carried out by the Tennessee Valley Authority in the United States has played a significant part not only in defence projects but also in helping the fertiliser industry to find cheaper and more efficient methods of production. Some of these achievements are discussed in this article.

THE chemical engineering research and development programme of the Tennessee Valley Authority, based largely on the Fertiliser-Munitions Development Center maintained at Muscle Shoals, Alabama, is important to the United States since it affects both national defence and national agricultural and industrial progress. In all these fields there have been considerable developments in recent years.

For nearly half a century the United States Government has recognised the national character of the fertiliser problem and the chemical facilities at Muscle Shoals were established in 1916 to produce nitrate munitions in time of war and fertilisers and fertiliser ingredients in peacetime. With the associated power facilities at Wilson Dam, they ultimately became the nucleus of the T.V.A. Fertiliser-Munitions Development Center, and, under the T.V.A. Act of 1933, play an essential part in carrying out the Authority's broad responsibilities for the conservation and development of natural resources.

The main building of the new chemical engineering plant at Muscle Shoals has an area of 89,000 sq. ft. and houses about 275 members of the research, engineering design and administrative staffs. The Authority also operates the nation's only full-scale fertiliser experimental laboratory, with facilities for research on all scales from laboratory test tubes to full-size factory units.

Contributions to defence programme

The technical and operational assistance given to the Army Chemical Corps in connection with its programme for the production of "nerve gas" is thought by the T.V.A. to be perhaps its greatest contribution, in the field of chemical engineering, to national defence in recent years. In this project the Authority has participated under conditions of secrecy since 1950 and in 1954 prepared to undertake for the Army Chemical Corps the operation of a new phosphate development works for the manufacture of compounds to be used in making "nerve gas" at a western arsenal. While the plant was being built near T.V.A.'s chemical plants at Muscle Shoals, engineers carried out extensive research and development work on problems involved in producing the compounds. For more than a year, about half the T.V.A.'s chemical engineering research and process development activity was devoted to it, resulting not only in important technical and economic improvements in the local plant and process, but also in the completion of pilot-plant development of a new process used by the Chemical Corps elsewhere.

Chemical research by the T.V.A. has also contributed to the atomic energy programme. In a co-operative project with the Atomic Energy Commission, the Authority has carried out research into the building of a full-scale demonstration plant for making fertiliser and recovering uranium from Florida " leached zone " phosphate, a plentiful overburden ore hitherto discarded in mining operations because of its high aluminium content. At the request of the A.E.C., in 1951, the Authority had already developed through the pilot-plant stage a process for the dual utilisation of this material.

At least seven private manufacturers of ordinary superphosphate are now using the results of another T.V.A.-U.S.D.A. (United States Department of Agriculture) research project undertaken at the request of the A.E.C. in its explorations for sources of uranium. Though not proving economical for the specific purpose required, the research enabled superphosphate producers to adapt their plants to produce a better grade material by substituting for the sulphuric acid commonly used either phosphoric acid or a mixture of phosphoric and sulphuric acids.

Phosphorus developments

These current direct contributions to national defence augment the past wartime efforts of the Development Center. During the first two years of the Korean fighting, the T.V.A. provided more than 7,500 tons of elemental phosphorus for military purposes at a time when supply was short. Earlier, in World War 2, it supplied nearly 60,000 tons of elemental phosphorus for military purposes. Its research work in the electric-furnace pro-

duction of phosphorus helped private industry to produce another 40,000 tons. The Authority also provided large quantities of ammonium nitrate for munitions, and, by a process of adaption worked out in co-operation with the U.S.D.A. and industry, contributed large amounts of the material for use as fertiliser. Large amounts of calcium carbide were also provided for the manufacture of synthetic rubber, while dicalcium phosphate was produced to take the place of bone meal.

Other wartime aids to national defence were the development of a continuous process for converting liquid white phosphorus to red phosphorus; the development of better catalysts for ammonia plants; two processes for extracting alumina from common clays; and a process for extracting magnesium from olivine, though the need for this metal was eventually met from other sources.

Fertiliser processes and equipment

One of the basic objectives of the T.V.A.'s chemical engineering research is to assist the industry in providing more and better fertilisers at lower cost. The Authority obtains patents on its developments and grants non-exclusive licences to all who wish to use them. In 1954, it obtained its 102nd patent on processes and equipment.

During that year, too, 28 licences were granted to industrial concerns, five being for the use of T.V.A.'s continuous mixer for superphosphate manufacture and 23 for a new process for the ammoniation of superphosphate and fertiliser mixtures. Altogether, 42 licences had been granted for the use of T.V.A. chemical engineering developments, with several companies having licences covering more than one development. In addition, more than 1,000 persons with technical interests visited Muscle Shoals for information during 1954. Further information was also provided on request to companies in 37 of the 48 states and in 24 foreign countries. Many articles are also published in technical journals.

Occasionally, the T.V.A.'s work in the fertiliser field helps an entirely different industry. For example, a zinc company recently found the Authority's electric furnace drawings of considerable help in designing furnaces for the production of high-grade titanium slag.

Within the phosphate industry the development of the electric furnace has done much to stimulate the production of pure phosphorus, the latest type being the rotating furnace, built since the war, which produces cheaper phosphorus than other units of similar size. In the United States the industrial capacity to produce elemental phosphorus has increased from 24,000 tons p.a. in 1934, when the T.V.A. started production, to 310,000 tons in 1953. In 1934 three companies produced this material, one using the blast-furnace method. Now, seven companies, all using electric furnaces, are producing it. At least four of the companies have plant equipment—electric furnaces and phosphoric acid units—based on T.V.A. designs. Two major producers operate plants which were built with the assistance of T.V.A. designs, engineering data, and operating experience in the Tennessee phosphate fields. Another company built a large rotating electric furnace in Florida based on a T.V.A. development.

Research by the T.V.A. has assisted industry in beginning the development of the phosphate reserves of the west. These reserves in the mountains of Idaho, Montana, Wyoming and Utah are the largest in the United States, containing about 60% of the total, and are of great importance to midwest agriculture. Hitherto, however, they had been little used because the concentration was low and processing expensive. The present western development began immediately after World War 2, when the Authority was asked to test low-grade Idaho phosphate rock, then discarded in mining high-grade rock, in a small, pilot-plant electric furnace. On the successful outcome of the test, the T.V.A. provided the operating company with furnace drawings, engineering data, etc., which were used to build the first phosphorus furnace in the west. At the end of 1954, three large companies were operating seven furnaces in Idaho and Montana, and an eighth was under construction in Idaho.

Substantial and increasing amounts of phosphoric acid made from elemental phosphorus are now finding their way into United States fertiliser manufacture, in contrast to the situation a few years ago. Then, none but that produced by the T.V.A. was so used, the commercial output being used to produce higher-priced chemical products such as detergents. In 1954, the T.V.A. produced 26,920 tons of elemental phosphorus, about 10% less than in the previous year, production having been curtailed because of the drought-reduced power available. The entire 1954 output was used to manufacture calcium metaphosphate and concentrated superphosphate.

By-products of electric furnace operation include calcium silicate slag, potash-phosphate ash and ferrophosphorus. Since the T.V.A. discontinued the washing of clay from the Tennessee phosphate about the beginning of 1954 the slag produced has too high an aluminium content to make a good liming agent. About 7,200 tons of expanded calcium silicate slag, a by-product of testing a new T.V.A.-developed process, was sold as a lightweight aggregate for concrete blocks. New slag expansion facilities were being built at the end of 1954.
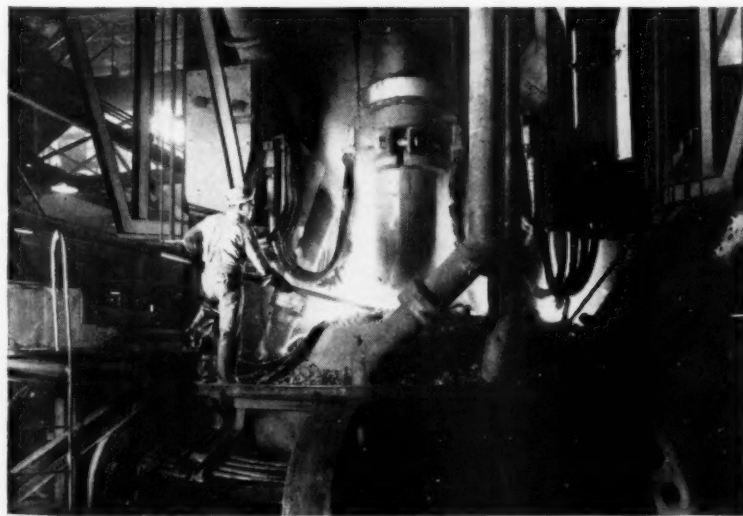
A view inside the T.V.A. experimental fertiliser plant at Muscle Shoals.

Nitric phosphate fertilisers

Although nitric acid has been used for some time in Europe for fertiliser production, this has not been the case in America. Two new commercial plants, however, using a process developed by T.V.A., commenced production of nitric phosphate fertilisers during 1954, and are the first of their kind in the United States. Allied Chemical and Dye Corporation began the operation of a plant at Muscle Shoals to produce 60,000 tons' annual capacity at South Point, Ohio, for producing a fertiliser containing 12% each of phosphate, nitrogen and potash. Associated Co-operatives, Inc. began to operate a plant at Muscle Shoals to produce 60,000 tons p.a. of a 14-14-14 fertiliser. A few other companies have certificates of necessity to build nitric phosphate plants. The interest taken in the process since the sulphur shortage a few years ago may be judged by the fact that the T.V.A. distributed nearly 900 reprints of seven articles on its nitric phosphate developments. In these processes, nitric acid, or a mixture of nitric and phosphoric acids, replaces all or part of the sulphuric acid ordinarily used in America to make phosphate fertiliser, the nitric acid giving the extra advantage of adding nitrogen to the product.

After a widely attended demonstration at Muscle Shoals early in 1954, at least 18 fertiliser companies were using or planning to use a continuous ammoniation process developed by the T.V.A. to add low-cost nitrogen to superphosphate or fertiliser mixtures. Fourteen companies had been licensed to use the process and nine companies to manufacture the equipment for sale. The continuous process is an improvement in efficiency over the batch method and more nitrogen can be added, giving an improved product, lower costs and greater benefit in use.

Ammonia production is rapidly expanding in America and capacity is expected to have doubled in two years by about the end of 1956. In this the T.V.A. has played a leading role in providing technical information. Test demonstrations in the use of ammonium nitrate, which at the T.V.A. is now all made by a vacuum crystallisation process, has helped to expand the market in this commodity, which is now the most popular solid form of nitrogen fertiliser in the United States. The Authority's own ammonium nitrate production, at 188,300 tons in 1954, amounted to less than 4% of the national production of nitrogen fertiliser.

Miscellaneous fertiliser projects

Plans have recently been made by T.V.A. to commence plant-scale demonstrations of a process for making diammonium phosphate, a fertiliser of high concentration containing both phosphate and nitrogen. After the plant had begun operation late in the 1955 fiscal year production of concentrated superphosphate and ammonium nitrate was planned to be reduced accordingly. Two grades of diammonium phosphate will be made: one containing about 21% nitrogen and 53% P_2O_5, and the other, a conditioned, granular product, having somewhat less concentration.

Recently, too, pilot-plant research has been started on a process for producing ammonium metaphosphate, a fertiliser containing a 90% concentration of plant nutrients—approximately 17% nitrogen and 73% phosphate. Phosphorus, air and ammonia are the ingredients.

Having been largely instrumental in bringing about a tremendous expansion in the industrial production of concentrated superphosphates from about 68,000 tons in 1934 to over a million tons in 1954, with further expansion still taking place, the T.V.A. considers that its technological, agricultural and commercial objectives in this field have been achieved. Its process development was, in fact, regarded as being technically completed several years ago. The Authority has therefore decided to reduce its production of this particular commodity.

At 104,000 tons, its 1954 out-put was nearly 25% less than in 1953.

The development of calcium metaphosphate, which contains about three times as much plant nutrient as normal superphosphate, had reached the stage of a plant-scale demonstration unit in 1949. The production and sale of calcium metaphosphate has increased rapidly in recent years and demand is now in excess of supply. Nine fertiliser producers have recently been given technical information on the process and one is considering building a plant in the west.

The major technical engineering problems involved in the large-scale production of fused tricalcium phosphate having been solved and its agricultural value fairly well established through experiment station tests and farm demonstrations, the T.V.A. now regards its work on this fertiliser as completed and is making preparations to sell its plant located at Columbia, Tenn.

J. GRINDROD.

Recent Publications

Synthetic resins and emulsions are discussed in a periodical bulletin of Scott Bader & Co. Ltd. which gives news about the company's products and their uses in industry.

Dust collectors. It is particularly to meet the needs of the smaller industrial boiler house, with special reference to the obligations of the factory owner under the provisions of the Clean Air Bill, that the *Sirocco* R-type dust collector has been designed. Details are contained in a pamphlet from Davidson & Co. Ltd.

Miniature instruments. A range of miniature electrical measuring instruments of various types are described in a catalogue (Section A) issued by Measuring Instruments (Pullin) Ltd. These instruments are designed to meet the demand for small round, square or rectangular pattern instruments suitable for mounting on a panel or in a portable desk stand.

Air-operated pumps, valves and accessories are the subject of a catalogue issued by Charles S. Madan & Co. Ltd. The *Airhydropump* produces hydraulic pressure from a small volume of compressed air and is claimed to provide an answer to testing problems requiring static hydraulic pressure and to many requiring a steady flow at a preset pressure. The unit is portable, compact and fully automatic in operation and there are 34 standard models giving an overall pressure range of 20 to 27,000 p.s.i. The catalogue also features a series of hydraulic control valves, designed for use with the *Airhydropump* and similar hydraulic systems.

Thermoplastic raw materials. From BX Plastics Ltd. comes a handy folder giving data on the company's range of products including rigid sheet, flexible sheet, moulding powders, monofilaments, packaging materials, materials for vacuum moulding, extrusions, special panels and shapes, and solutions.

Kittel plates are a new type of plate for contacting vapour and liquid as required in the processes of distillation, absorption, direct gas cooling, scrubbing, etc. They are also used for contacting liquids of different densities as in continuous counter-current liquid/liquid extraction. Some details of these plates are given in a 16-page illustrated booklet from Costain-John Brown Ltd. Photographs and diagrams assist in explaining the construction and operation of the plates, while graphical data shows performance.

World News

British titanium now cheapest

A reduction in the price of their raw titanium to about 21s. (below $3) per lb. has been announced by Imperial Chemical Industries Ltd. This compares with the current price of $3.45 in the U.S.—at present the largest producer and user of raw titanium. The reduction means that I.C.I. is producing, by its new sodium process, titanium of the highest purity at what is now the lowest price in the world.

Only ten or twelve companies have so far entered the field of raw titanium production on a large scale, and there has been keen competition between them to improve extraction techniques so as to cheapen their product, which is the raw material for the producers of wrought titanium products for industry. In consequence, from a price of $5/lb. at the beginning of 1954, the price of first-grade titanium has dropped in five successive reductions to $3.45.

In August 1953, I.C.I. announced that they were going to build a plant to produce 1,500 tons of titanium a year by a new sodium process of their own development. The plant came into operation in 1955, less than two years after planning was started. I.C.I.'s titanium has important advantages in its physical form. Instead of the coke-like "sponge" of the conventional Kroll process, the titanium is in the form of small granules which can be pelleted with alloying materials into a form ideal for the difficult process of melting.

Coal and chemical engineering— international experts to meet

An international conference with the theme "Chemical Engineering in the Coal Industry", sponsored by the National Coal Board, will be held from June 26 to 29, 1956, at the Board's Coal Research Establishment at Stoke Orchard.

The conference will comprise four technical sessions: "The Physical and Chemical Pre-treatment of Coal", "Fluid Bed Carbonisation", "Briquette Carbonisation" and "Liquid By-Products."

As accommodation is restricted, attendance will be limited to scientists and engineers with a particular interest in this field, and will therefore be by invitation only.

New Zealand heavy-water scheme dropped

The United Kingdom Atomic Energy Authority, after consultation with the New Zealand Government, has decided to withdraw from participation in the Wairekei heavy-water scheme.

It has been found that the cost of constructing the heavy water plant would be much higher than was originally estimated.

Heavy-water technique for India

Costain-John Brown Ltd. have been appointed by the Government of India to advise them regarding the types of heavy-water plant which they should install to meet the forward commitments of their atomic energy programme. Their immediate needs may well be met by the installation of plants associated with nitrogen fertiliser factories.

The heavy-water plant constitutes a substantial portion of the Indian Government's projects, running into many millions of pounds.

The integration of heavy water production with the manufacture of fertilisers means that the heavy water may be produced for considerably less cost than other methods, such as that proposed for the New Zealand Wairakei scheme where it was to be produced in conjunction with the generation of electric power.

Tower box purifier for gas works

A tower box purifier to be installed at the Beckton (London) gas works will be one of the largest units in the country. It will be 215 ft. long, 76 ft. high and 100 ft. wide, and will be constructed from 4,000 tons of welded steel. The North Thames Gas Board is spending over £500,000 on the purifier, which will treat 30 million cu.ft. of gas daily. Henry Balfour & Co. Ltd. have signed the contract to erect this plant. Work should be completed in two years.

This will be the third plant of this type that Henry Balfour have installed for the North Thames Gas Board; two similar, though smaller, plants are operating successfully at the Southall and Bow Common gas works.

The plant, which is mechanically operated, consists of a hugh welded steel container, sub-divided into 15 tower boxes, each containing 16 trays, each tray holding 33 tons of oxide,

whose purpose is to remove sulphur impurities from the entering gas. (The total amount of oxide in circuit is approximately 8,000 tons).

Gas enters each box through the large connecting mains, passes down through the oxide and is purified. It is then collected off and goes on to the remainder of the ancilliary plant. When the spent oxide in one of the boxes needs to be changed, this is performed automatically by a mechanical device which tips it from the trays, later recharging them with fresh oxide.

Boiler manufacturing developments

Packaged 'K' type boilers are being manufactured and sold by Davey, Paxman & Co. Ltd., under licence from Eerie City Ironworks, Pennsylvania, U.S. The 'K' type unit is a two-drum boiler and in its 'packaged' form covers a range from 2,500 to 17,000 lb./hr. of steam from and at 212°F, in 10 sizes.

Representatives of the technical press were recently able to see the 'K' type boiler in operation at Paxman's Britannia works at Colchester. They were also taken on a tour of the company's Standard works, also at Colchester, where this and other boilers were in course of production. An additional feature in the Economic boiler field is the all-welded boiler. The fabrication of rotary vacuum filters and the manufacture of Class 1 fusion-welded pressure vessels is also carried out by Paxman, and this work was seen in progress. The equipment at Colchester includes two of the latest submerged-arc welding machines, which can deposit weld metal at a rate not less than six times that of hand welding, an important feature being that deep penetration is possible with practically no distortion.

New Chair of Chemical Engineering

Prof. Frank Morton has been appointed to the new Chair of Chemical Engineering in the Faculty of Technology at Manchester. The new Department at Manchester has a very well established tradition, lectures in chemical engineering having being given by Mr. George E. Davis in the school at Granby Row as far back as 1880, while chemical engineering has been taught in the Department of Applied Chemistry since 1933. It is hoped that the creation of a Chair of Chemical Engineering at Manchester will lead to the expansion of the Department and it is expected that in

the very near future plans will be announced for a new building which will house the Departments of Chemical Engineering, Metallurgy, Fuel Technology, and Nuclear Engineering. In this expansion the co-operation of industry will be needed if the College is to fulfil its dual function of training honours graduates in technology and providing part-time "sandwiched" courses for technologists in industry.

Prof. Morton has been Professor of Chemical Engineering at Birmingham since 1949. Between 1936 and 1945 he served with Trinidad Leaseholds Ltd., in the West Indies, and between 1945 and 1948 he was chief chemist to the company, at their London office.

Activated carbon recovery plant

British Carbo Norit Union Ltd. and Whessoe Ltd. have made an agreement for the supply of plants for the purification of gases and the recovery of vapour phase solvents.

The agreement will link the knowledge of the use of activated carbon possessed by British Carbo Norit Union with the chemical engineering and manufacturing abilities of Whessoe who will now be carrying out contracts in this field. It is expected that this development will result in advances in the design and building of purification and solvent recovery plants and in the techniques of adsorption.

New tonnage oxygen project

A further tonnage oxygen project at Middlesbrough has been announced by British Oxygen. News of one tonnage oxygen plant was announced last October; the company now states that very large oxygen plants of the most up-to-date type will be installed on a site which has been recently acquired on Tees-side, and the plant installed initially will be able to produce between 250 and 300 tons/day of oxygen.

The installation will include a large tonnage oxygen gas plant, expected to be in operation early in 1957. Other plants on the site will be put into operation before that date.

INDIA

Government loan for chemical project

It is understood that the Government of India have agreed to grant a loan of Rs.2½ crores to Fertilisers & Chemicals Travancore Ltd., This will enable them to double the capacity of their ammonia plant to 80 tons/day and increase their capacity for ammonium sulphate to 100,000 tons p.a. and sulphuric acid to 80,000 tons p.a.

GERMANY

Potash industry

With world demand for potash rising steadily, the West German potash industry's export prospects are considered promising, particularly in Asian and African markets, according to an industry spokesman. A further rise in output is therefore being planned for the current year, despite a decline in sales in 1955.

Total sales last year are estimated at about 1,570,000 tons (in terms of K_2O), against 1,590,000 tons in 1954.

BELGIUM

Opening of Purfina research laboratories

The official opening took place recently of the new research laboratories of Laboratoire de Recherches Purfina, S.A., a member of the Petrofina group of oil companies. Situated on the outskirts of Brussels, they are the first laboratories to be set up in Belgium exclusively for research for the oil industry. They will be concerned with a very wide range of activities including research into hydrocarbon deposits and their development and exploitation, the selection of manufacturing processes and the study of problems connected with the manufacture and industrial applications of the products of the Petrofina group.
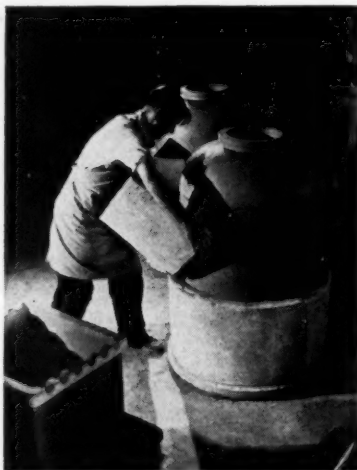
Stripping the plaster mould from a chemical stoneware store jar at the Wilnecote, Tamworth, works of Doulton Industrial Porcelains Ltd., a subsidiary of Doulton & Co. Ltd. During the past few years the manufacture of various Royal Doulton industrial ceramics has been gradually transferred to Tamworth from other units and the company reports that the operation will be completed this year when the Lambeth works, established in 1815, will finally close.

EGYPT

Aswan fertiliser plant

Egypt has accepted offers from two West German and four French firms to build a £E20/million fertiliser plant at Aswan, Upper Egypt. The French firms are Schneider (Forges et Ateliers du Creusot), Matériel Electrique S.W. Air Liquide, Compagnie Générale d'Electricité, and C.I.T.R.A. The German firms are Badische Anilin und Soda Fabrik and Friedrich Unde. Work is expected to take five years, with one-third of the plant ready to start operations early in 1960. Full production is expected to be 370,000 tons of nitrate per annum.

LEBANON

New chemical enterprise

A new company, Société des Produits Chimiques du Liban has been formed with a capital of £Leb. 8 million for the manufacture of artificial ammoniac, citric and sulphuric acids and chemical fertilisers, etc.

SOUTH AFRICA

Manganese mining

After a lapse of 80 years it is hoped to resume manganese mining operations in the Du Toit's Kloof Mountains, about 30 miles from Cape Town. The permission of the Department of Mines has been obtained, but it is still necessary to obtain the permission of the Department of Forestry, on whose ground the mine is situated. If this is obtained the mine, closed when transport expenses became too heavy, will be reopened on behalf of the Consolidated African Mines Ltd. It is planned to build a road from the mine to near the national road in the Du Toit's Kloof Pass, 1½ miles away.

RHODESIA

Nickel discovery

A vast nickel bed, believed to be the largest nickel deposit in the world, was struck at Ingondama, 40 miles south-west of Gatooma in Southern Rhodesia, recently. It is estimated that the yield of the proposed mine will be about 8 million tons of ore for every 100 ft. of depth. Present plans envisage the sinking of a plant which will employ 200 Europeans and about 2,000 natives. It is stated that the ore is similar to that obtained from the well-known nickel mine in Sudbury, Ontario.

BRAZIL

Chemical project

The German and American groups Farbwerke Hoechst A.G. and W. R.

Erecting a Drying Plant in the South African Bush

*T*HE big new phosphate plant of the *Phosphate Development Corporation (Pty.) Ltd., at Phalaborwa in the Transvaal was described by a South African correspondent in our December issue, and in this article the wildness of the site was referred to. Some details that have now come to hand concerning the erection of a rotary louvre drying installation to handle 400 tons/day phosphate concentrates give an interesting picture of the difficulties encountered.*

The installation is situated in wild bush country, 1,300 ft. above sea level and over 400 miles from Johannesburg. The nearest rail head is 24 miles away and the auxiliary equipment manufactured in South Africa had to be delivered by road. The equipment exported from the United Kingdom was transported by road from Lourenco Marques, the distance being about 260 miles, and it took 54 hrs. to do the relatively short journey in view of the difficult conditions. It was not possible to keep in close touch with the job by telephone or by post, and the engineer, based in Johannesburg, who visited the site to supervise the erection of the drying plant, travelled 8,000 miles in eight weeks. As though all this was not enough, there was a good chance of meeting a bad-tempered bull elephant
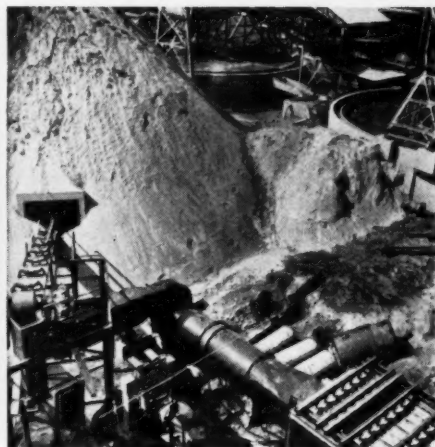
Left: **Engineers discuss ways of moving the rotary louvre drier drum into position.**
Right: **View of the phosphate plant at Phalaborwa showing phosphate dump, feed elevator and tunnel, part of furnace and part of reduction works.**

or some other unfriendly creature on the road leading to Phalaborwa.

The accompanying pictures give some idea of the nature of the site and of the difficulty of erecting the rotary louvre drying installation, which was supplied to Foskor by Dunford & Elliott Process Engineering Ltd. The plant was erected by the latter company's agents in South

Africa, Steam & Mining Equipment (Pty.) Ltd., The rotary louvre drier is 8 ft. 10 in. in diameter and 25ft. long. Hot air is supplied from a coal-fired combustion chamber complete with under-feed stoker and temperature control equipment.

The concentrates fed to the drier vary in size from 65 to 325 mesh.

Grace and Company are building a DDT factory in Sao Paulo, which should go into production this year.

Initial annual production is set at between 2,000 and 3,000 tons, which represents about 75 per cent of current Brazilian consumption.

The plant will also produce monochlorobenzene, caustic soda, solvents and detergents, according to reports from Sao Paulo. The enterprise represents a capital of $6 million, of which two million will be spent on Brazilian products.

NORWAY
Titanium deposits

Further deposits of titanium ore were reported to have been discovered in the neighbourhood of Jossingfjord and borings indicate a volume of over 100 million tons of ore.

ARGENTINE
New chemical plant

The Central Bank has authorised the Pfizer Corporation of the US to invest 5 million dollars for the establishment of a local plant for the manufacture of chemicals and pharmaceutical products in Agentina.

★ PERSONAL PARAGRAPHS ★

★ Thompson Bros. (Bilston) Ltd., announce that following the retirement of **Mr. A. J. Lowe** from the London office after 36 years' service as manager, they have appointed **Mr. C. W. Wiles** from the Bilston headquarters as manager of the London office.

★ **Mr. J. Arthur Reavell** of Kestner Evaporator & Engineering Co. Ltd., returns from his visit to South Africa at the beginning of April.

★ **Mr. L. Bomyer** has relinquished the appointment of chief engineer to Ronald Trist & Co. Ltd., but continues as the director responsible for technical matters and production. Mr. Bomyer's appointment as chief engineer is assumed by **Mr. R. G. Allen.**

★ In the furtherance of the overseas expansion plans of Harrisons & Crosfield Ltd., **Mr. G. F. Cumming,** M.B.E., T.D., (manager of Harrisons & Crosfield's Chemical Division and director of Durham Raw Materials Ltd., an associated company,) has been appointed to the board of Dillons Chemical Co. Ltd., Montreal. The latter is an associated company of

Harrisons & Crosfield (Canada) Ltd., **Mr. G. O. Peake,** O.B.E. has also been appointed to the board of Dillons.

OBITUARIES

★ The death of **Sir Hubert Houldsworth,** Q.C., D.SC., chairman of the National Coal Board since 1951, will be noted with regret by a great many people both inside and outside the coal industry. Sir Hubert, who began life in humble circumstances, took a science degree at Leeds University as a young man and seemed destined for a brilliant academic career. However, he was later called to the Bar and eventually, through his interest in mining law, became connected with the coal industry. He was Controller General in the Ministry of Fuel and Power from 1944 to 1945, and Chairman of the East Midland Division of the N.C.B. from 1946. He was created a Baronet in the 1956 New Year Honours.

★ **Mr. H. A. Tippetts,** chairman and joint managing director of Birwelco Ltd. and Brown Fintube (G.B.) Ltd., died recently. He was 67.

British Patent Claims

The following are abstracts reproduced from the weekly Patents Abstracts Journal *by permission of the Technical Information Co. The complete specifications can be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, price 3s. each.*

Chromic anhydride

Addition to Brit. Pat. 724,246. In the manufacture of chromic anhydride by precipitation of anhydride crystals from an aqueous solution of alkali metal dichromate, using concentrated H_2SO_4, the crude crystals with adhering mother liquor are separated and mixed with sufficient solid dichromate or saturated solution thereof to react with the free H_2SO_4 in the crystal mass, the resulting mixture is fused and then allowed to stratify in the molten condition to form an upper layer of dross and a lower layer of pure anhydride crystals, and the dross and anhydride are finally separated and recovered. — 739,760, *Diamond Alkali Co. (U.S.).*

Electrically-driven pump

The stator element of an induction motor is removable from its mounting, in operative association with a rotor on the pump shaft, without disturbing the fluid-tight characteristics of a housing enclosing such rotor and shaft. The housing includes a fluid-tight shell of non-magnetic material located between the rotor and stator, and the latter is mounted on a frame rigid with the housing independently of the shell.—739,537, *Food Machinery & Chemical Corp. (U.S.).*

Gas-cleaning apparatus

In a combined mechanical dust separator and electrostatic precipitator (*e.g.* for flue gases), in serial arrangement, means are provided for introducing gas at a controlled rate into the dust-collecting chamber below the depending centrifugal separator tubes of the mechanical separator, such gas flowing upwardly through the tubes without passing through the gas-spinning element therein, and serving to regulate the pressure drop across the tubes.—739,567, *Research Corp. (U.S.).*

Centrifugal dust separators

In a separator having dust-separating cells of the return-flow type arranged in parallel to the flow of gases through the separator, and each cell having a gas outflow tube, fine dust deposit is removed from the walls of those tubes by supplying coarse dust particles to the gas inlets of the cells by lowering the dust separating efficiency of the cells, whereby the coarse dust particles flow out through the tubes and exert a scavenging action thereon.—736,320, *J. Howden & Co. Ltd.*

MEETINGS

Institution of Chemical Engineers

March 10. 'Efficiency and Wetting Characteristics in Perforated Plate Columns,' by Prof. F.H. Garner, S.R.M. Ellis, and J.W. Hill, 3 p.m., College of Technology, Reynolds Hall, Manchester.

March 13. 'A Study of the Motion of the Solid Phase in a Solid-liquid Fluidised System', by N.L. Franklin, 7 p.m., Grosvenor Hotel, Chester.

March 21. 'Some Aspects of Continuous Processes in Organic Synthesis', by J.W. Woolcock, 7 p.m. the University, Leeds.

Society of Chemical Industry (Chemical Engineering Group)

March 13. 'The Use of Reinforced Plastics in the Chemical Industry and Some Chemical Problems Connected Therewith ', by A. de Dani, 5.30 p.m., Geological Society, Burlington House, London, W.1.

March 28. ' Some Aspects of the Use of Radio-isotopes ', by F. Seligman, 6.30 p.m. Geological Society.

Institution of Mechanical Engineers

April 6. 'A Standard Gas Turbine to Burn a Variety of Fuels ', by G.B.R. Feilden, J.D. Thorn, and M.J. Kemper, 5.30 p.m. 1, Birdcage Walk, London, S.W.1.

The Fertiliser Society

March 22 ' Good Quality Granular Fertilisers—Some Research and Manufacturing Problems ' by B. Raistrick, 2.30 p.m., Geological Society, Burlington House, London, W.1.

Incorporated Plant Engineers

March 21. ' Plant Instrumentation and Electronic Control ', by R.P. Townsend, 7 p.m., Bull Hotel, Rochester.

Institute of Fuel

March 21. ' Steam Raising from Waste Heat', by C. Ungoed, 2.30 p.m., Engineers' Club, Albert Square, Manchester.

March 22. ' Hydrogen Peroxide and Rocket Fuels ', by W.S. Wood, 7 p.m., Royal Technical College, Glasgow.

Society of Instrument Technology

March 27 'Atomic Energy Plant Instrumentation ', by R.K. Sandiford, 6.30 p.m., Mansion House, Portland Place, London, W.1.

March 21 ' Instrumentation in the Oil Industry ', 7.30 p.m., the Rotunda, Cheltenham.

March 28 ' Recent Instrument Developments ', by J.W. Drinkwater, 7 p.m., 5, Kings Buildings, King Street, Chester.

INTERNATIONAL CONFERENCES

March 12-16. Twelfth Annual Conference, National Association of Corrosion Engineers, New York.

March 22-23. Symposium on "The Extraction Metallurgy of Some of the Less Common Metals", Institution of Mining and Metallurgy, London.

Sampling (B.S. 2635: 1955, 2s. 6d., 'Drafting specifications based on limiting the number of defectives permitted in small samples '). This publication is a valuable contribution to the solution of problems of sampling for industrial specifications. It is intended chiefly for the assistance of those concerned in the drafting and use of clauses in specifications based on a statistical analysis of the results of sampling, particularly with small samples.

WHAT'S NEWS *about*

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in one of the attached postcards, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

Lightweight flexible ducting

A lightweight, reinforced ducting, available in diameters from 3 to 30 in., is constructed of a spring steel helix secured between overlapping plies of various multi-coated fabrics such as cotton, jute and glass, with rubber, neoprene, silicone, etc., and suitable either for pressure or exhaust ventilation, fume removal and conveyance of dust and light solids. It is extremely light in weight, yet of robust construction, flexible and retractable down to 10% of its extended length. In spite of its extreme lightness and flexibility, it will not kink at bends and can be installed or dismantled with the minimum of trouble.

The ducting, known as *Spiratube*, is available in standard lengths of 10 ft., 15 ft. or 25 ft., but can be supplied in any length up to 25 ft. for special applications. In its various forms it is suitable for temperatures from –80 to +450°F. and is resistant to oils, flame and abrasive materials.

A newer product, *Flexflyte*, is of somewhat different construction, and is available in diameters from 1 to 4 in. *Flexflyte* is constructed of a steel wire helix, with inner and outer plies of impregnated glass-fibre fabric. It is supplied in standard lengths of 12 ft. which can be cut to shorter lengths at the site. **CPE 182**

Ultrasonic mixing

An ultrasonic mixer, said to be no more complicated either in construction or in application than conventional electric mixers, is known as the *Polytron*. The equipment consists essentially of a rotor and stator, comprising two shallow co-axial cylinders, the walls of which are formed by rings of specially shaped steel teeth. The outer ring is static, while the inner is rotated at high speed by a universal motor, the annular clearance between the rotor and stator teeth being small.

The design of the system is such that high-frequency vibrations of considerable power are generated. Frequencies up to 240,000 c/s. may be obtained with standard models.

The system is claimed to be capable of operation over a wide range from low viscosities of the order of water up to stiff pastes and emulsions. Standard equipment is available up to a motor power of 1.5 kw. suitable for container capacities of 250 l.

The mounting may be in the top or bottom of the tank, autoclave or other vessel. Cutter heads can be fitted for the direct processing of coarse materials in liquid media into finely dispersed suspension. More powerful motors are available for special purposes.

Smaller portable models suitable for laboratory application are available in several sizes ranging down to a micro disperser permitting the treatment of minute quantities of fluid in a 12-mm. test tube. **CPE 184**

TEMPERATURE CONTROLLER

This mercury-in-steel-operated temperature controller is for ranges covering –30 to +1,200°F., or Centigrade equivalents. It has been designed to meet applications where accurate and constant temperatures are essential; for example on annealing ovens and chemical process plants.

The complete unit consists of the following equipment:

(a) Remote reading mercury-in-steel thermometer fitted with single electric contact adjustable over the full scale.

(b) Relay unit suitable for a rating of 10 amp. at 230 v. a.c. Suitable units for higher ratings are available if required.

(c) Two coloured warning lights (green and red) are fitted for normal and operating conditions.

(d) The above is housed in a suitable wall-mounted case with blue-grey hammered enamel finish as standard, with alternative colours available.

(e) Provision for cable entry is provided in the bottom of the case by means of two ¾-in. E.T. bushes, and a suitably designated terminal block is fitted to take external cable connections.

(f) Various types of capillary tubing and bulb fittings are available. **CPE 183**
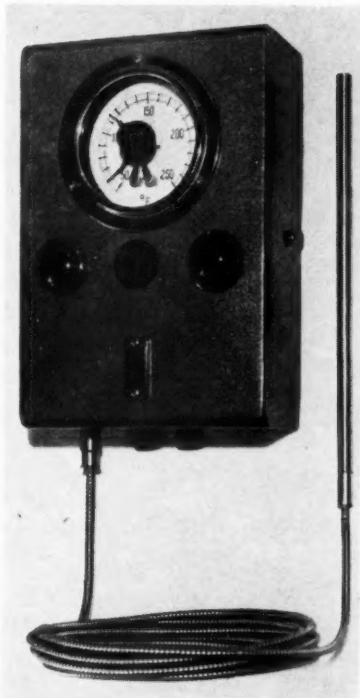
'Off-the-shelf instrumentation' with these miniature instruments

Complementary to their useful size, some of the miniature instruments available today offer a brand-new conception of process instrumentation. 'Off-the-shelf instrumentation' is one realistic description applied to the *Tel-O-Set* range of miniature instruments, which include a standard pneumatic indicator, recorder and controller for all process variables. Separate pneumatic transmitters for most variables are within the manufacturing company's range.

Tel-O-Set instruments are unit-constructed to permit simple replacement of major sections. But unit construction is only one aspect of the 'unit' approach to modern instrumentation made possible by the introduction of these instruments. The makers point out that the design of future process instrumentation need only involve the selection of the required number of *Tel-O-Set* units.

One of the most interesting features of the new instruments is the flexible operating relationship between recorder (or indicator) and controller. A flat gasketed surface at the rear of the recorder matches up perfectly with the controller, which has a single-lever quick-disconnect switch. The controller can be mounted in the back of the recorder, behind the instrument panel, or at a remote location. All controller adjustments are readily accessible from the rear.

Proportional and integral control actions of the *Tel-O-Set* controller are easily adjusted; the instrument offers a simple choice of three integral action times—slow, intermediate and fast. Derivative control is readily added to the basic model.

Several features have been included with a view to anticipating the requirements of operators and service engineers. A full 8-hr. chart record is visible when the chassis is withdrawn; with the chassis partially or completely withdrawn, the instrument remains fully operative. A horizontal scale above the chart provides a continuous indication of control air pressure to valve even when the recorder chassis is completely removed. The location of control knobs ensures that manipulation (from front of panel) does not obscure the view of pointer or scale. Automatic chart re-roll, giving 30-day process record and daily chart tear-off, are available as alternatives.

Another example of flexible design is the interchangeability of the recorder and indicator chassis. The need for instrument cases of different colours is eliminated by an interchangeable bezel on the front of the instrument.

The *Tel-O-Set* recorder requires a panel cut-out measuring only $5\frac{1}{32}$ in. $\times$ $4\frac{9}{16}$ in. This small area accommodates all that is usually visible of an instrument designed to meet the most exacting process requirements.

CPE 185

Hard-working pump

The *Pneu* pump is one of the simplest ever invented and it will operate for years without attention, say the makers. It is a compressed-air-operated pump of novel design in which the only moving part is a ball valve. It is stated that the pump is particularly suited for pumping sludges and slurries and that hot, practically boiling liquids are pumped without difficulty.

Only a small volume of compressed air is required to operate the pump efficiently and, by means of a simple anxiliary apparatus, it can be operated from a steam supply.

The standard model is made in steel; other versions are available in chemical stoneware and in stainless steel, while further variations are the rubber-lined or lead-lined models.

The pump consists of an enclosed vessel having non-return inlet valves of very simple design. Compressed air is led to the vessel by a pipe connection either from an existing supply


'Pneu' pump in chemical stoneware.

main or, if this is not available, from a small motor-driven compressor unit. A vertical delivery pipe carries the liquid away under the action of the compressed air. Inside the vessel and coupled to the discharge pipe is a special seal pipe which controls the action of the pump.

The *Pneu* pump is of the drowned inlet type and can be arranged either in a wet or dry sump with suitable inlet connections. Liquid enters the vessel through the inlet valves until it has filled. The special seal pipe then fills and closes the vessel to atmosphere so that compressed air builds up a pressure within the vessel and ejects its contents.

When the vessel is empty the seal pipe opens and exhausts the compressed air through the pipe along which the liquid has been expelled. When this happens the delivery pipe is cleared of liquid, the pressure is relieved and the pump can then refill from the sump in readiness for the next cycle. The final phase of each delivery cycle is a rapid spurt of air and liquid which prevents any blockages in the pipes.

An output of up to 15 gal./min. is obtainable. **CPE 187**
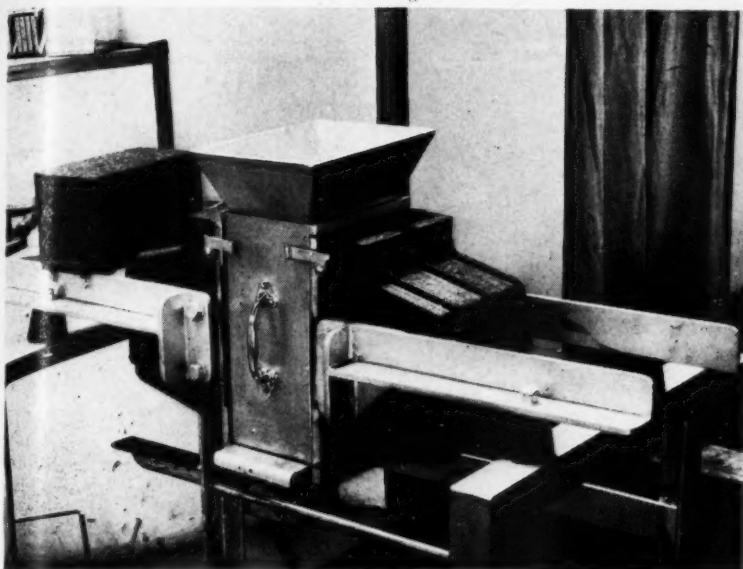
REMOVING FERROUS PARTICLES FROM POWDERS AND LIQUIDS

The picture shows a Blencut, *self-contained, magnetic filter unit which has been designed for the removal of finely sub-divided and feebly magnetic ferrous particles from all kinds of powders, granules and liquids. Filters are manufactured in a range of four sizes and are fitted with grids. The grids are available in different types and sizes to suit the varying characteristics of materials. They are housed in a filter box, the whole of which becomes magnetised when in the magnetic zone created by the twin super-intensity permanent magnetic units and become non-magnetic when withdrawn from this field.* **CPE 188**
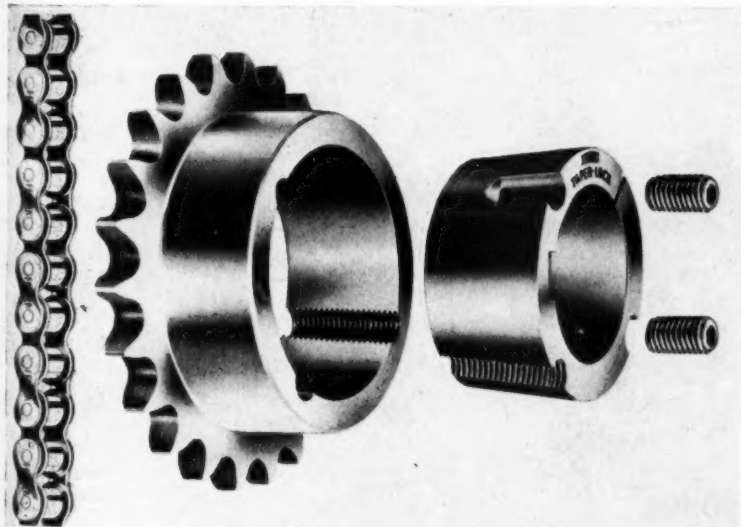
TAPERED BUSHES

For the first time, British engineers have the easy mounting facilities of tapered bushes in chain sprockets. A British company announce that Taper-Lock *bushes have been applied to a standard range of chain pinions and wheels, and that they also have roller chain available.*

Chain drives for most industrial applications are thus now ready for use, without any remachining or the need for skilled fitting.

These bushes are all interchangeable, not only in chain sprockets, but in V-pulleys and flexible couplings. **CPE 189**

New fittings cut pipe-welding costs

New seamless, stainless-steel fittings are known as *Forjends*, this name covering long-radius, standard-weight elbows and return bends and standard-weight equal tees, reducers and caps in accordance with B.S. 1640 and American Standard A.S.A. B 16.9, together with flanges to B.S. 1560 and American Standard A.S.A. B 16.5.

The material is to A.S.T.M. A.312, types 304, 316, 321 and 347, and the wall thickness to Schedule 40 of American Standard B 36.19, which is applicable to stainless steels.

These fittings are so designed to cut the cost of pipe welding by making it possible to greatly facilitate the laying out, lining up and welding. The seamless construction means no welds over welds.

The following features are combined in the new fittings:

(1) *Seamless.* Forged and formed seamless.

(2) *Uniformly full pipe thickness.* All sections are at least full pipe thickness and there is no thinning at the back wall. They are therefore made for uniform strength.

(3) *Tangents.* Their design removes the necessity of welding on the curved section and makes all welding a simple straightforward operation.

(4) *Bevelled ends.* Provide a clean, accurate welding surface that ensures a better job.

Extensive, intricate systems of pipelines in refineries, chemical plants, etc., are quickly assembled with only girth welds, and the use of *Forjends* allows installations to be erected very close to walls of buildings. **CPE 190**

Acid-resistant plant

An all-round service in the design and construction of ' acid-proof ' plant and vessel linings, floorings and protective coatings is offered by a company which operates in Britain and overseas. The manufacture and application of chemical-resistant cements and membranes is only one facet of this company's field of activities and a full service in corrosion engineering is provided. This includes the design and construction of plant and structures. **CPE 191**

Paint withstands acids, alkalis and gases

Protection against acid fumes, corrosive gases and fluids in factories and on steel structures is provided by *Supruba* chlorinated-rubber paint. This paint has been used for overhead steelwork and woodwork in a number of gas undertakings, and the makers claim that it is the only protective coating which has been formed to withstand the adverse atmospheric conditions common to gas works. They further state that the paint is particularly suitable wherever protection from the chemical content of the atmosphere is required.

Chlorinated rubber is insoluble in water; hence the film has good impermeability to water and water vapour. In addition, the dried film is non-toxic, non-inflammable, has excellent heat-resisting qualities and a good electrical insulator. Decomposition of the film occurs at temperatures over 270°F.

These types of paints may be applied by brush or spray, although the rapid drying factors of the material makes brush application a little more difficult than with an oil or synthetic paint. It is also pointed out that the gloss of a chlorinated-rubber paint is rather less in lustre than a hard-gloss type of material.

Surfaces to which, when they have been correctly primed, chlorinated-rubber paint can be applied include all types of metal, wood, plaster, asbestos, hardboard, cement and brickwork.

CPE 192

Flameproof limit switch

A flameproof limit switch which can be used in collieries where Class I gases are present is stated to be safe also against Class II and III gases, which include blast furnace gas, hydrocarbons encountered in the petroleum industry, liquids derived from coal tar, many industrial solvents such as cellulose solvents, coal or town gas and coke-oven gas.

The flameproof *Snap-Lock* switch is a single-phase, or d.c. double-circuit, or two-way switch having one normally closed and one normally open circuit, which can be reversed by moving the return spring to the side required. With the return spring removed completely, the operating lever must be used to reset the switch or make contact in the opposite position, thus providing a double-throw switch which is maintaining in both positions.

The operating lever is mounted on a splined shaft which enables the easy removal and repositioning of the lever, while the splines are such that the operating lever can be adjusted for position in steps of $7\frac{1}{2}°$ throughout a full circle.

To comply with the National Coal Board's directive that no aluminium die casting may be used in dangerous locations, the switch is housed in *Meehanite* iron castings. Provision is made for mounting the switch by two $\frac{5}{16}$-in. B.S.W. tapped holes, one on each side face.

Instead of the usual separate flameproof terminal chamber, which would have been so small as to be inconvenient, a four-pin plug and socket has been introduced and adequate provision is made to prevent this being wrongly assembled. The body of the plug forms the sealing chamber, which is filled with bituminous filling compound after connection of the user's steel armoured cable, thus preventing moisture from percolating down the strands. The end of the sealing chamber forms one side of the bolted-on anchorage for the steel armouring.

An improved design of plug-and-socket contact has been utilised. The contact elements are silver plated and provide sufficient contact area to carry the heaviest load specified for the switch with an adequate additional safety margin.

The switch is operated by $10\frac{1}{2}°$ movement of the operating lever, which has an effective length of $1\frac{1}{2}$ in.

CPE 193

Filter for fluids

A sintered filter of unique design and considerable versatility has made its appearance in the U.S. Made of sintered metal and capable of handling fluids ranging in temperature up to 1,000°F., the new filter can remove particles as small as one micron in size.

The one-piece sintered element can be made in a variety of diameters and lengths and its radial-fin construction can be supplied in specified depths and numbers of convolutions to give extended area within a confined space. Varying flow rates are also available. Filters of stainless steel, *Monel* and other metals can be made as required.

Other features of the new filter are its controlled permeability and uniform porosity, which can be varied as to pore size desired. It can handle differential pressures of up to 500 p.s.i.

CPE 194
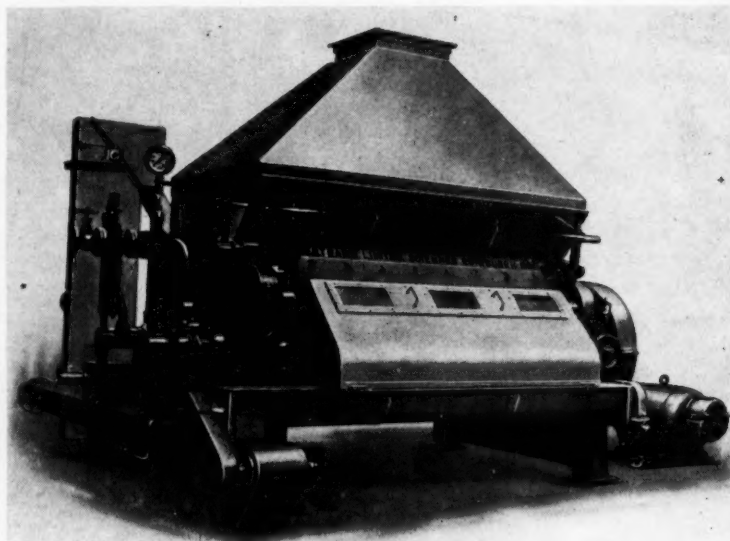
DRYING ANILINE DYES

The twin-cylinder drying machine illustrated here is designed for the drying of aniline dyes. All parts of this machine which come into contact with the liquid dyes fed to the drying cylinders are of stainless-steel construction. The conveying and handling equipment for the dried product is also of stainless steel, having hinged dust-proof covers on the side conveyors adjacent to the cylinders. A stainless-steel vapour hood with hinged inspection flaps is arranged over the machine. **CPE 195**

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